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CONTENTS

General Reviews and Summaries:

Electrical Phenomena of the Skin: CARNEY LANDIS, 693. *An Evaluation of Fifteen Radio Talks in Psychology by Means of Listener's Reports:* F. H. LUMLEY, 753.

Books Received: 765.

Subject Index: 768.

Author Index: 769.

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THE
PSYCHOLOGICAL BULLETIN

ELECTRICAL PHENOMENA OF THE SKIN

(GALVANIC SKIN RESPONSE)

BY CARNEY LANDIS
New York State Psychiatric Institute

Since the appearance of the general review of the literature on this subject by Landis and DeWick (1929), two hundred forty-seven additional titles have appeared. In the present review we have considered seventeen papers which were also reviewed or cited in the previous bibliography. These papers either bear directly on the interpretation of the more recent findings or else were not considered in the 1929 review. There has been a constant increase in the number of papers appearing on this general subject. However, when the annual number of papers on this subject was compared to the total annual number of psychological articles listed in the *Psychological Index,* we found that the relative percentage remained about constant.

Since there is so much confusion and inexactitude with regard to the nomenclature used in this field, I have proposed the following definitions (Landis, **8**) and have attempted to adhere to them in this review:

"*Electrical phenomena of the skin:* Any change in the electrical properties of the skin as shown by any electrical measuring or indicating device. According to the best present-day knowledge, these changes are the end-products of complicated neurological, biological, chemical processes.

"*Galvanic skin response:* (1) Decreased apparent resistance of the skin due to physiological activity under the control of the autonomic nervous system, following sensory or ideational stimulation. (2) Increase in the apparent electromotive force of the skin similar to (1). [(1), called the phenomenon of Féré; (2), called the phenomenon of Tarchanoff. Both (1) and (2) are essentially

sweat gland phenomena associated with the mechanism of bodily temperature control. Under certain conditions circulatory and trophic influences are important factors. Either (1) or (2) may be demonstrated by means of a galvanometer and usually are recorded by a photokymograph. The record is a wave-like curve having a latent period of 3–5 secs. and a duration of 3–15 secs.]

"*Psychogalvanic reflex:* An historical term used to describe the phenomena, defined under the term 'galvanic skin response,' but without the exactitude demanded by this definition."

In all other cases I have attempted to comply with the usual electrical and biological terminology.

Historical

During the past three years, a few papers on this subject, which are of historical interest and which were not previously considered, have been found. Among these are papers by Silva and Pescarolo, Féré, Müller, Gregor (1), Abramowski (3), and Binswanger. Silva and Pescarolo anticipated many of the physiological findings emphasized by more recent workers. The pioneer work of Féré is summarized in his book entitled "La Pathologie des Émotions" (1892), which appeared in an English translation in 1899. When one considers the exaggerated and uncritical statements which Féré made in this book, it becomes more apparent why his so-called discovery drew so little scientific attention. The paper of E. C. Müller is interesting in that it anticipated many of the findings made and proclaimed as new some twenty years later. Just why this paper escaped previous cross-reference in the literature is not clear. The Binswanger reference is an English translation from the original German articles which appeared in 1908 and 1909. The remarks of Gregor (1) are of historical interest because of their moderation at a period in which everything was being claimed for this "reflex." Aptekmann's article is the journal publication of her doctral dissertation, which was taken up in the review by Landis and DeWick. Abramowski (3) reported, in a study of the normal subconsciousness, that one is able to investigate emotional reactions of forgotten or subconscious memories by means of the galvanic response. His results are directly in line with those reported by Jung, Prince and Peterson, and Binswanger.

Gildemeister (2) has made a summary of the history of the physiological and anatomical work on this subject. Comel, in a lecture to students of dermatology, summarized much of the work which has been done on the galvanic skin response, and interprets it in the light of Gildemeister's experimental work.

Landis (5) has made a special study of the historical background of the work in this field. It is his contention that there is nothing in the older literature to justify the commonly accepted belief that this response is to be identified with emotion or with any other particular psychological category. He presented evidence showing how this peculiar scientific fallacy gained belief and general support.

Lauer (4) in a study of the titles of the psychogalvanic literature concluded that the term "psychogalvanic reflex" is both inexact and a misnomer, and has been used so loosely that it has no semblance of scientific exactitude. Landis (8) arrived at somewhat similar conclusions and offered definitions and terminology which have been adhered to in the present review.

Methodology

General: Both Linde and Banerjee have reviewed with some care the methodology and technique which has been used by various investigators of the "psychogalvanic reflex." Their conclusions and recommendations are based on the older and cruder work. Neither one considered the more recent and fundamental work which has been carried out, either with the high frequency currents or with the various types of vacuum tube amplification. Zimmern, Walter and Nyer have described an apparatus for use in demonstrations of the psychogalvanic reflex. It is only a slight modification of the usual Wheatstone bridge and seems to have no particular advantages except for use in demonstrations.

Regelsberger (2, 9) discussed in detail the methodology and apparatus to be employed in polarization measurements of the human skin. He pointed out various possible sources of error and showed how they may be avoided. His work seems scientifically sound and of importance to those interested in this type of measurement. Ebbecke (2) has made use of an ingenious method of measuring the E.M.F. or polarization of the skin. He made use of a "wick" electrode for his applied potentials, and measured the skin changes with separate electrodes at varying distances from the applied potential. In this way he was able to investigate the spread of the electrical field of the applied current. Keller and Rein studied the polarization of the skin which results from X-ray or ultraviolet irradiation, using apparatus of a very high sensitivity.

Fabre (1), and Fabre and Swyngedauw (2, 5) have made use of a cathode ray oscillograph in the measurement of resistance and capacity, using potentials which were applied from very brief periods of time. Strohl (1, 12) devised an "Egersimetre" which was used

as a circuit interrupter, giving a very short (1/10,000 sec.) pulse of current.

Gondet, and Strohl (12) have developed theoretical circuits, which give results equivalent to the electrical phenomena shown by the human body when interposed in an experimental circuit. These circuits will be discussed below.

Boyd has recently taken up the study of the static electrical field of the human body. This subject received some attention previous to 1905, but has since been neglected.

Circuits: Quite a number of new electrical circuits for use in the study of electrical responses of the skin have been devised and made use of during the past three or four years. Davis (2, 3, 4) has made use of vacuum tube amplification and oscillographic recording of these phenomena. Davis and Porter described a circuit which possessed the advantages of giving galvanometer deflections proportional to the skin response. The exosomatic current may be varied at will but, when set, will remain constant. Thus, a continuous record of the subject's total resistance may be obtained without putting the subject in a separate measuring circuit. Dubost (1) gave the details of an oscillographic circuit by which impedance may be measured quickly and with extreme accuracy. Hathaway (1, 2) has devised a circuit making use of vacuum tube amplification with a 60 cycle alternating current for the applied potential and current supply. He held that records obtained in this manner were not marred by polarization, a point which is open to question. Davis and Porter questioned the validity of the Hathaway circuit. Bellingham, Langford-Smith and Martin also have made use of a vacuum tube circuit for the demonstration of these phenomena.

Thouless has used a circuit in which the applied frequency could be altered between zero and 5000 d.v.s. and found that the "reflex" disappeared or was too small for measurement above 5000 d.v.s. Peserico (2) made use of frequencies as high as a million cycles per second in analyzing the resistance of polarizable membranes. McClendon (3) has used similar high frequency measurements to study the impedance of living tissue. Dugge used a new direct current circuit for the measurement of the resistance of the human body. Harris has described a vacuum tube circuit which has been used by Buytendijk and Eerelman.

Galvanometers: Hathaway's (1, 2) apparatus is cited in several recent papers, as providing a new galvanometer. This, of course, is not accurate, since in reality he has a new circuit using an ordinary milliammeter. Davis (4) has used a cathode ray oscillograph for

recording this phenomenon. This instrument represents the most sensitive and rapid method of electrical recording now available. Broxon and Muenzinger have used a quadrant electrometer, which is an old-fashioned static instrument and which has the advantage of measuring potential differences without passing any applied current through the electrodes. While they stated that this particular instrument had not been used previously, the method of recording without the use of applied potentials is not new.

Electrodes: The search for a truly non-polarizable electrode still continues. But all the evidence goes to show that there is no particular reason why anyone should hope to achieve true non-polarization. Numerous electrodes which are relatively non-polarizable have been worked out for various purposes during the past century. Slight proposed one of the simplest and most convenient electrodes for this variety of work, which has appeared in recent years. Ruckmick and Patterson, and Bayley have proposed and used modifications of the "mercury-mercurous chloride-saline" electrodes, which are adapted to the particular needs of the galvanic experiments. Ruckmick (2) has also designed a simple electrode for use with the Hathaway apparatus. Lauer (1, 2) designed two new types of electrodes. McClendon and Hemingway (1, 2, 3) have described a circuit and a method of attaching the electrodes so that whatever polarization takes place may be counteracted. Lullies made a study of the polarization effect of various electrodes used on the skin of the frog. His results showed that the phenomenon of polarization, taking place between the electrode itself and the skin, is a complicated affair. Bujas (1) pointed out that the electrodes must be kept at very nearly bodily temperature in order that polarization may be kept at a minimum.

Keller (1, 2, 3) has given a great deal of attention to the influence of the ionic concentration of the electrode material upon the results obtained in polarization measurements. He found that rinsing the skin with very dilute acids before applying the electrodes brought about no change in E.M.F. but, if the acidity of the solution was increased, a negative-to-positive effect would be obtained. Using slightly alkaline solutions, a positive-to-negative effect resulted. These acidity effects were not shown by concentrated solutions but appeared only with weak ones. If the fingers were soaked in water previously, they became strongly positive when measured with respect to any other portion of the body. Measuring the changes of the electrodes themselves, while the subject was exercising, showed that the ionic saturation of the electrolyte increased more than could be

explained by mere concentration due to absorption of sweat. He explained the effect as the result of cation enrichment, which in turn was due to sweating plus diffusion through the electrolyte.

Strohl and Desgrez (3), and Strohl and Portes studied electrodes made up of various anion and cation concentrations. They showed that the value of the initial resistance depends in part on the chemical nature of the electrode substance traversed. In general, the resistance varies inversely with the chemical concentration of the electrolyte. They recommended that for most exact work one should make use of low E.M.F.'s, short time intervals, and low chemical concentrations. Swyngedauw found that the effect of electrodes, containing increasing concentrations of NaCl, was directly proportional to the resulting potential of the skin. When he made use of other anions and cations, he was able to show that the counter-potential of the skin was usually proportional to the valence of the salt used in the electrode. He obtained a potential difference of as high as 60 millivolts between the fingers when one was in sodium sulphate and the other was in aluminum chloride.

Dubost (2) has shown that the maximum phase angle displacement of applied alternating currents was obtained with small electrodes and that it varied inversely with the area of the electrode surface.

Strength of Current: Davis (1, 3) found that the galvanic reaction increases in size with the increase of the applied current, but not in direct linear proportion to the current. Thouless (1) reported that the maximum possible polarization of the skin is about 33 volts.

Bachem, in a study of the electrical resistance of certain of the organs of the dog, has shown that resistance measurements should be made with very low applied potentials, as the higher E.M.F.'s give rise to heat variation and consequent distortion of the resistance records.

The Physical Nature of Galvanic Skin Phenomena

Physical Causes: In the older literature it has been very frequently pointed out that these electrical phenomena of the skin were artifacts, due to the electrodes themselves, or to slight muscular movements, etc. The paper by Ochorowicz (1915) is an interesting example of this type of criticism. He held that the galvanic reflex is primarily caused by the vibration between the electrodes and the skin, which vibrations were due to subconscious reflex movements. Bujas (1) had a somewhat similar idea, maintaining that the reflex is

due to chemical changes between the skin and the electrode, based primarily on temperature variations. Cattell (2) hoped to obtain from a large number of experiments knowledge concerning the relationship between variations in resistance and various conscious processes. He was unable to fulfill this ambition, but he did show that the size of the deflection decreased by about 5 per cent for every increase of 10,000 ohms in apparent resistance in the skin. With his particular measuring circuits the actual apparent resistance of the subjects varied between 7,000 and 250,000 ohms.

The conclusions of Gildemeister (1) have furnished the starting point for a large amount of work during the past two or three years. Gildemeister demonstrated that the changes in apparent resistance of the human skin were due to alterations in polarization capacity and, furthermore, that these electrical changes were a matter of a mixture of diffusion capacity and double layer capacity, in which the double layer capacity varied. Polarization capacity means a capacity in parallel with a resistance and may be represented by a leaky condenser. For example, if one determined that the impedance or effective resistance to a high frequency current was 900 ohms and that the polarization capacity of the resting skin was 0.035 microfarads and 10,000 ohms, then on stimulating another part of the body with a painful stimulus the polarization capacity might be changed to 8,800 ohms and 0.0357 microfarads.

McClendon (1), and McClendon and Hemingway (1, 2, 3) have investigated with exceedingly well planned technical procedures the physical basis of the resistance of plasma membranes, such as constitute the walls of sweat glands. They have shown that, when the apparent resistance to a direct current changed 13.7 per cent during the reflex, the resistance to a million cycle current changed only 0.93 per cent. For practical purposes then, it may be assumed that the resistance to a very high frequency current does not change during the reflex.

Strohl (2, 3, 4, 5, 9, 10, 11, 12, 13, 14), Strohl and Desgrez (1, 2, 3), Strohl and Dubost, and Dubost (1) have been interested in the underlying factors producing the electrical resistance shown by the human body. This long series of papers may be summarized as follows: Strohl considered that the tissues act in the same manner as an electrostatic capacity. He gave reasons to show that Gildemeister's hypothesis of a double layer capacity is not adequate or thoroughly convincing. He believed that the resistance and capacity of the human body to a current is best represented by circuit A as shown in Figure 1. In this circuit the resistance at R_x is equivalent to that offered by the

interior of the body; the resistance r_1 R_1 c_1 is that of the epithelial portion of the skin and that of c_2 R_2 r_2, the dermal and sudorific portion. The "psychogalvanic reflex" is due to an alteration in the resistance and capacity of R_2 and c_2, which represent the membranes of the sweat glands. In one of his papers (9), he showed equivalent circuits for the skin of the frog, excised human skin, and the skin

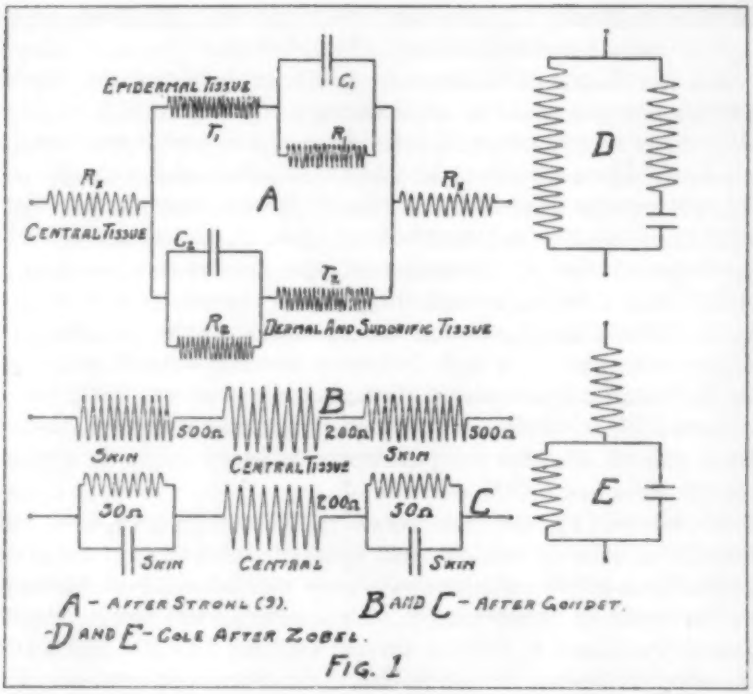

FIG. 1

plus the entire body. He also demonstrated in several of his papers that the length of time during which the current is applied to the skin, the size of the electrodes, and the chemical nature of the electrodes all have an important bearing on the resultant resistance measurements. It is possible, by means of Strohl's findings, to predict with a reasonable degree of accuracy the probable resistance of an area, if all of these contributing factors are known. He has also, together with his collaborators, investigated the distortion of the electrical waves of an alternating current, which is brought about when the current traverses the human skin. Dubost (1) made a special study of the effect of measurement made by currents of low alternating frequency. He demonstrated that the initial resistance of the body depends upon the size of the surface of the electrode and

not upon any other factor. The apparent deviations from this fixed figure were due to technical artifacts set up in the measuring circuits.

Fabre and Swyngedauw (**1, 3, 4, 5, 6, 7**) and Swyngedauw, by technical methods different from those of Strohl, have made a study of the capacity, resistance, and polarization of the human skin. Their findings, although in some parts different from those of Strohl and his co-workers, were in essential agreement. They maintained that the initial resistance is constituted by the interior of the body, and that the resistance of the skin occurs later in the electrical measurements when these measurements are made at very high speeds. They have also shown that the depolarization curve of the skin is not symmetrical with the polarizing current.

Gondet has taken up the findings of various investigators and has demonstrated the physical analogue of the resistance of the body under a variety of conditions. He showed quite convincingly that such a circuit, as is shown in A of Figure 1, explains conduction under certain conditions. The circuits for high (Fig. 1 C) and low (Fig. 1 B) frequency alternating currents are likewise distinct. The low frequency analogue is probably that of three resistances in series, two of which are represented by the skin at the point of attachment of the two electrodes and the third by the central resistance. When high frequency currents are used, the central resistance remains unchanged, but the resistances represented by the skin are altered so that they act as a capacity in parallel with a rather low resistance.

The work of the French electrophysiologists (Strohl, Fabre, *et al.*) has carried on the investigation from the place where Gildemeister's (**2**) experimental work left it in 1925. These investigators have shown the effect of the various tissues involved in the conduction. They have been able to rule out much of the effect of technical artifacts which have caused so much trouble in this field. Our basic knowledge of the electrophysiology of the skin certainly has been advanced by these investigators.

Cole (**1, 2**) has investigated the basic electrical properties of simple protoplasmic suspensions such as those of Arbacia eggs. He showed that certain types of two terminal net-works can be made equivalent in impedance and phase angle for all frequencies. As a result of this, such circuits, containing any number of resistances and a capacity, can be made equivalent to either one of the two simple circuits D and E in Fig. 1. Because of this, the number, location and magnitude of the elements can not be determined solely by the electrical measurements at the terminals; and the number of circuits

which are possible to fit the data is limited only by the patience and the ingenuity of the computer. His data indicate that the specific resistance of the interior of the egg is about 90 ohms per centimeter or 3.6 times that of sea water, while the impedance of the surface of the egg is probably similar to that of a polarization-capacity.

Regelsberger (2) has investigated the polarization phenomena of the skin, showing that the polarization capacity is regulated by similar laws to those of the static capacity of a condenser. This polarization capacity, *i.e.*, the ability of the skin to store or hold an electrical current as a result of electrolytic dissociation, is an important factor in the study of the physiological changes of the membranes of the cells of the skin. He has shown that the change in polarization capacity, which is involved in the galvanic skin reflex, is due almost entirely to the membrane action of the sweat glands.

Saitō (1, 2) has shown that the variations in polarization capacity, which are brought about by the effect of adrenalin, pilocarpine, ergotamin, etc., may be interpreted as the result of stimulation leading to an increase in the permeability of the glandular skin cells. The effect from adrenalin is primarily upon the sweat gland structures, while the pilocarpine effect is upon the mucous glands. He interpreted his results in light of Gildemeister's hypothesis, namely, that the polarization capacity is mainly a diffusion capacity, which may be interpreted as due to a lowered polarizability of living cells of the skin. This conclusion is contrary to the interpretation of Strohl. Hōzawa (3) has made a theoretical analysis of these electrical phenomena of the skin in the light of Nernst's theories of electrophysiology (a di-phasic electrolyte).

The condenser capacities obtained by measurement of the living skin were made by Peschkowsky. He found that the stratum corneum of the skin is the seat of the condenser capacity. He also showed that the changes in polarization capacity are in no way related to erythema of the stimulated part. The polarization capacities of the various layers of the skin were investigated by Lullies. He showed that the fixed capacity layers are most probably in the epidermis, while the changeable layers with respect to polarization consist of the living dermal tissues. The gaps in the fixed layers act as an electrical shunt. By means of physical and mathematical computations Lullies believed that he separated the effect of the individual parts of the skin in polarization.

Keller (4) investigated the potentials of the skin of various areas of the body, using a variety of electrodes. His discussion is quite technical. He showed, in general, that the potentials are due to the

local action of the skin under the influence of sympathetic nervous innervation. These responses are complicated by the nature of the electrodes and by the texture of the skin at the point of attachment. Williams, studying the effect of X-ray irradiation upon the frog's skin, showed that there was a rhythmic rate of recovery or loss of vitality following such dosage, which can be measured in terms of the electrical potentials of the skin.

Rein (1, 2, 3, 4), who was interested in the physical basis of the electromotive force of the skin, made use of new methods for measuring the changes in ionic permeability of the skin under varying conditions. He found that the electromotive force depends largely upon the diffusion of tissue skin fluids through the membranes. He presented several equations governing the behavior of the electrical potentials which may be set up. Certain of the changes he found to be due to temperature alterations in the skin. Darrow (2) has shown that the galvanic skin reflex gives a correlation as high as +0.93 with simultaneous records of sweat secretions and of thermo-reactions in the skin.

Albrecht (1910) held that the origin of the electromotive force of the skin was at the juncture of the electrode with the skin. He believed that the fluctuations in electromotive force were dependent upon secretions of sweat, which influenced the chemical balance between the skin and the electrode. This doctrine still is frequently quoted in the literature. However, the work of McClendon and of Rein, cited above, shows that the skin itself possesses an electromotive force. Gelfan has shown by means of microelectrodes, inserted into a single living cell, that a difference of potential between 0.002 and 0.004 volts may be found between different parts of the same cell. This potential seems to be dependent on the streaming of the protoplasm and is the reverse of electro-osmosis. Telkes reported similar findings.

Dickson and Bennett-Clark held that the resistance of plasma membranes could be simulated by emulsions of oil, water, oleic acid, and calcium oxide or sodium hydroxide. It seems possible that further work along this line will give us greater insight into the chemical nature of electrode phenomena.

Munk and Flockenhaus reported that the degree and distribution of the potential differences of human skin are essentially the same for all individuals. Under the same conditions of distribution, this potential difference is symmetrical with respect to bodily areas. Between symmetrical points of the body there are very small or no differences. These differences are influenced by bodily temperatures

and by the variation in locality and quality of the skin. Thouless (1, 3) has gone into this problem more thoroughly than did Munk and Flockenhaus. He has shown that the complex form of the appearance of these potential differences indicates that different physiological components with different time relationships are basic. He has also shown that the relationship between the variations in potential difference and the variations in apparent resistance are related in a very complex fashion, and that it is almost impossible to study one without giving close attention to the other. Gildemeister (2) treated this problem in detail.

Boyd made a study of the static potential of the skin of the human body. The body was grounded and protected by copper shielding, and the various areas were explored with insulated electrodes. He found differences in potentials which did not show a gradation towards the earth. When the skin was covered with paraffin oil, the difference in potential was still found, indicating that friction was not a source. Needlepoint electrodes showed differences between adjacent spots. Hence, he concluded that these static potentials must be due in part to minutely localized surface activity or to activity internal to the surface of the skin.

Physical Factors Influencing These Phenomena

Certain of the physical factors which influence these galvanic responses have been discussed in the previous treatment of the physical causes of the phenomena. The work of Darrow (2), Peschkowsky, Bujas (1), Boyd, etc., are examples of this.

Dugge (1, 2) has presented some interesting results, showing the influence of the weather upon the apparent resistance of the human skin. He maintained that during a rapidly decreasing barometric pressure, such as occurs at the beginning of a storm, the electrical resistance of the body is increased, while in fine weather the resistance is relatively low. Similarly, damp weather produced high resistances. He attributed these variations to the effect of variations in thoracic pressure on the sympathetic and vagus nerves. Ueno studied the apparent resistance of the skin in factory workers. He was interested in developing the method so that it might be used to indicate fatigue. He noted the same diurnal variation in apparent resistance, which had been reported previously by Waller and others. He was cautious in drawing conclusions, but did find that the refractory period of the reflex may possibly be used as an index of fatigue.

Jones (3) has demonstrated the galvanic skin response in early

infancy, finding that it may be elicited, although it is smaller and less easily aroused than in older children. He interpreted this as due to both lack of physiological and psychological development. Ödegaard has made a particular study of the types of galvanic curves occurring in various psychopathic conditions. He presented evidence, showing that in the more serious psychopathic states the curves are the most atypical.

Darrow (4) has shown that the thermal and galvanic curves, obtained from identical skin areas, are practically identical in appearance. Both the electrical and temperature changes occur independently of blood volume changes. Purdy, Johnson and Sheard have presented evidence, showing that the skin potential is positively correlated with the basal metabolic rate in the range (metabolic) between +13 and —10. If the circulation of the skin is normal, the metabolic rate may be calculated within four points by a formula which they derived. Where the circulation is poor, this correlation does not hold. Their preliminary investigation indicated an inverse correlation between cutaneous temperature and differences in electrical potential. If these findings are confirmed and the working conditions standardized so that the results will be reliable, the method should be an extremely valuable one for the determination of metabolic rate. It has been shown by Regelsberger (1, 3) that the electrical potentials and polarization capacities of the skin are associated with differences in the reactivity of the skin to X-ray irradiation. Certain of the subjects gave a negative reaction and others a positive reaction (as compared to normal skin) from the irradiated area. He stated that constitutional factors were important in determining these groupings.

Comparison of the Methods of Féré and Tarchanoff: The work of Jeffress was cited at some length in the previous review, since he made a special study of the relationship between these two phenomena. As was pointed out, he reported that there was a very close concomitance of results so that one might use either curve to predict the other. The more recent work of Thouless (3) is in line with the findings of Jeffress. Thouless' findings showed that the earlier conclusions of Gildemeister and of Einthoven, which seemed to be contradictory, could be interpreted as supplementing each other when certain additional factors were taken into consideration. The work of Munk and Flockenhaus, which has been mentioned above, showed that temperature and bodily conditions influence this relationship between potential and resistance. The recent summary by Gildemeister (2),

concerning these relationships, will be discussed below under the heading of the "Physiological Nature of the Galvanic Response."

Anatomical Factors Underlying the Electrical Phenomena of the Skin

The previous review of Landis and DeWick showed both that the main neurological pathways underlying the response had been mapped out, and that the general location of the higher nerve centers controlling the response had been fairly well localized. During the past three years, a long series of papers by Wang and his co-workers and by Richter have gone far in establishing the precise pathways of the inter-relationship of the central control. Sakamoto (1, 2, 3), working with frogs, was the first to show that the galvanic response may be demonstrated when the brain has been destroyed but the spinal cord left intact. Richter (2, 3, 7) subsequently has shown that the response may be elicited in the cat after the spinal cord has been transected at any level below the mid-thoracic region. His work indicates that in the cat several weeks must elapse between the time of the transection and the time at which the experiments are made. This period of adaptation is one in which several rather well marked changes take place. Richter and Shaw showed that in the first stage after the operation the apparent resistance of the skin is very high, and the skin is dry and harsh to the touch. In the second stage the skin is soft and moist and the sweat glands are obviously functioning again, while the electrical resistance is as low or lower than it was before transection. At this time the galvanic response and spontaneous responses exhibit themselves. Richter (3) showed that if the sympathetic supply of the extremities is entirely removed, the resistance is approximately the same as if the entire motor nerve trunk supply were eliminated. This increase is not permanent but recedes to a lower level in about twenty days. The recession is not due to regeneration of nervous tissue. Tower and Richter have used this method to study the regeneration of sympathetic preganglionic neurons. Langworthy and Richter have studied certain of the influences of the brain upon the control of primary autonomic reflex paths. They found that definite galvanic skin responses may be obtained by faradic stimulation of two areas adjacent to the motor cortex, from the floor of the third ventricle, from the cortico-spinal and rubro-spinal tracts, from the vestibular nuclei, from the posterior column nuclei, and from the posterior columns of the cervical cord. Richter (8) has used various hypnotic drugs to investigate the cortical

and subcortical control of this response. He found no evidence to support the notion that these hypnotics could be differentiated into cortical and subcortical groups, but felt that the drugs owed a great deal of their action to their effect upon the sympathetic nervous system.

Wang and Richter, and Wang, Pan and Lu have investigated the galvanic response obtained by stimulation of higher nervous centers. They showed that any slight stimulation of the tuber cinereum produces electrical changes in the footpad of the cat, which are similar in form and latency to the galvanic skin response. Cutting the motor nerves to the paws abolishes the change, while stimulation of the cut end of the sympathetic nerve fibers produces the change. Animals in which the entire nervous system is intact have the shortest latent period of response, while the thalamic preparations have a slightly longer latent period, and the spinal preparations a still longer latent period. The extirpation of the cerebral hemispheres produces little change in the intensity of the response, while the removal of the thalami causes an enormous decrease in the intensity. No further change in intensity is caused by transection at still lower levels. They concluded that there are three main nerve centers for this galvanic response: cortical, thalamic, and spinal.

Wang and Lu (**1**, **2**, **3**, **4**, **5**) have continued this previous work of Richter and of Wang. They have shown that the conduction speed of the post-ganglionic sympathetic nerve fibers to the sweat glands of the foot-pad is about 120 centimeters per second. This speed is about 1/65th of that of somatic motor nerves. There is, however, a great deal of individual variation in these speeds, which probably is due, for the most part, to the difficulty in controlling the temperature of the skin served by the sympathetic nerve fibers. They were unable to produce inhibitory effects upon sweat secretion by stimulation of the dorsal spinal roots. A cortical center for the galvanic response was found in the motor area. The response, elicited by stimulation of this area, persisted after motor responses had been abolished by transection of the ventral and dorsal spinal roots. The response obtained from the excitation of portions of the frontal lobe (the orbital gyrus) was due to the spread of the stimulating current, either to the motor area or to the olfactory tract. The reaction obtained by stimulation of the motor area was larger in the ipsilateral extremities than for the contralateral. They hold that the neurones in the cortical sweat centers act directly on the spinal sympathetic preganglionic sudo-motor nerve cells and not indirectly through the inter-

mediate stations in the tuber cinereum. They studied the gradation of the response as related to the grading of the strength of the stimulus. Their results indicate that both the conduction in the post-ganglionic sympathetic nerve fibers and secretory activity of the sweat glands follow the "all or none" principle. The graded activity shown by the sweat glands themselves is due to the number of nerve fibers functionally active at the time of the response. Lu has shown that there is some overlapping in the innervation of the sweat glands of the cat's paw, which may account for a certain lack of specificity of response which is occasionally found. Wang and Mok investigated the production of the galvanic skin reflex when the stimulation was applied to the cortical motor area centers after spinal cord lesions. Their results suggest that the neurones in the cortical motor field are connected with the sympathetic pre-ganglionic sudo-excitatory neurones in both sides of the spinal cord by way of the descending fibers contained in the two direct and one crossed system of the cortico-spinal tract. They do not feel, however, that their evidence is fully confirmatory of this assumption.

Ebbecke (1) investigated the galvanic response during abdominal surgical operations. He found that the response could be elicited even in a state of deep narcosis if the stimulation was strong enough. The most effective form of stimulation was found to be that of pulling the peritoneum. He concluded that when the higher centers were blocked in their activity, the vegetative centers of the brain stem and of the spinal cord took over control. This is in line with the work cited above. Dugge (1, 2), following the work of Minor, showed that day-to-day variations in the resistance of the body were due to variations in barometric pressure which affected the pressure on the sympathetic and para-sympathetic nerves in the throat and thorax.

Weinberg (2, 3) has investigated the response as it is coördinated with electrocardiographic and plethysmographic records. As a result of his analysis, he indicates that the wave-like form of the galvanic response is due to: (1) The overbalance of the sympathetic division of the autonomic nervous system, (2) the overbalance of the para-sympathetic division, and finally, (3) the readjustment of balance. Peserico (1), studying the conditions of secretion of the salivary gland, arrived at conclusions essentially the same as those of Weinberg.

As was mentioned above, the work of Strohl (12) and Gondet has gone far to demonstrate the relationship of the structural anatomy of the skin to the electrical changes and properties shown.

The anatomical work has been summarized as follows by Wang: "From these physiological findings we know that when a receptor organ is stimulated, nerve-impulses are set up in its afferent nerves; that these nerve-impulses may be transmitted first to the cortical sweat area and then therefrom to the preganglionic sudo-motor neurones in the spinal cord; that these nerve impulses may be conducted first to the vegetative center in the tuber cinereum and then from there to the preganglionic sudo-motor neurones; that these nerve-impulses may be directly sent to the preganglionic sudo-motor neurones in the cord; that the nerve-impulses conducted by the preganglionic neurones activate the post-ganglionic sudo-motor neurones in the sympathetic ganglia, which in turn transmit them to the sweat glands; that when the sweat glands are excited by these nerve-impulses and begin to secrete, the galvanic skin reflex appears."

The Physiological Nature of the Galvanic Response

The Effect of the General Physical Condition of the Body: Müller in 1904 pointed out that the variability in the electrical resistance and in the galvanic response of the human body depended upon such factors as the time of day at which the measurements were made, the habits of the subject, the nervous or mental state of the subject and of such physiological phenomena as forced respiration, changes in blood circulation, etc. Experimenters have repeatedly confirmed these observations of Müller. The diurnal variation has been recently investigated by Ueno in an attempt to study and measure the effect of fatigue in various working conditions. Ruckmick (**2**) has discussed these same fatigue phenomena. Richter (**1, 4, 5**) has been investigating the variations in apparent electrical resistance of the skin during sleep, narcolepsy, and similar conditions. His original contention, that there was a marked increase in electrical skin resistance during sleep and a decrease in resistance on awakening, was questioned by Landis (**1**). Further investigation on the part of Richter (**1, 4**) has resulted in the modification of certain of his earlier statements, although he still holds to his major premises. Richter, in his earlier papers, failed to adequately describe the method and exact procedure which he used in making measurements of electrical skin resistance. He stated that these measurements were made by means of a string galvanometer, and that his electrodes were zinc plates on which a paste made of zinc sulphate solution and kaolin had been placed. Whether the electrodes were removed and replaced after each measurement, whether they were left to dry slowly, or whether they were moistened at intervals, has not

always been reported; while the conditions of the experiments make it certain that differences in procedure must have occurred. Richter (**5**), in 1929, stated that he measured resistance indirectly by means of the deflection of the string galvanometer to a potential of one millivolt. This being true, the results of Landis (**1**) are in no way comparable to those of Richter, since Richter's method is in no sense the usual way of measuring resistance. In view of the divergency of results obtained by the use of the two different methods, it would be well worth while to investigate the physical and electrical circuits as used by Landis (**1**) and by Richter (**5**).

It might be noted here that the diagram (Fig. 1) in Landis (1) is erroneously drawn, and also, that the use of a 60 cycle alternating current would in no way obviate polarization and give readings of true resistance, which Landis thought he obtained by this method. This correction regarding polarization is based on the more recent work which has been cited above, under the heading of "Physical Causes of the Galvanic Response."

Richter (**4, 5**) stated that the skin resistance in narcoleptic patients was much higher and of a different form from that of normal individuals or patients in hysterical or catatonic stupors. The effect of alcoholization and of bromides upon normal individuals was investigated by Brun. He found that alcoholization diminishes the galvanic response, and that this diminution is more marked to affective than to indifferent stimuli. Ingestion of bromides reduces the response even more than does alcohol.

Peschkowsky has investigated the effect of iodine, mustard plasters, 25 per cent ammonia, a 2N sodium hydroxide solution, and brushing with a dry brush, on the polarizability of the skin. All of these irritants affected markedly the polarization capacity. Hōzawa (**2**) applied chloroform and ether in various solution strengths and found that at narcotic concentration levels, a temporary reversible decrease in cell permeability and polarization takes place; whereas higher concentrations, reaching toxic levels, increase the permeability irreversibly.

Regelsberger (**4, 6, 7**) has investigated the diurnal variations in the polarization capacity of the skin. He showed that this variation in rhythm is altered in such pathological states as Parkinson's or Basedow's disease. The curves, which he obtained upon normals, are strikingly similar to the diurnal rhythm of temperature and of the CO_2 content of the blood. The fact that two groupings appear in response to X-ray irradiation, he feels is evidence of the constitu-

tional types of vagotonia and sympathicotonia. Strauss (**1, 2**) has made use of measurements of the electrical potential of the skin, as a method of indicating the degree of fatigue. He held that the size of a potential drop during exercise is not a measure of fatigue, but rather that the rate of return to a normal potential after exercise is a measure of recovery from fatigue.

The relation of muscular tensions to electrical skin resistance has been investigated by White, who asked the subject to tense all muscles of his body for ten minutes; to squeeze a dynamometer as tightly as possible for ten minutes; or to work multiplication problems mentally. He found that there was a higher electrical resistance in relaxation than in tension. Since his muscular tension might be expected to arouse the activity of the sweat glands, and since such activity is accompanied by a decreased electrical resistance, his results are in line with expectation.

Bachem showed that the studies of electrical resistance made on live tissue are not directly comparable to those made on dead tissue, since pronounced changes occur at death. Dumas, in a rather popular article, discussed the secretion of sweat and the production of goose flesh in emotional states. His observations are based on clinical evidence and explained in terms of the histological hypothesis of Franck.

Physiological Processes Causing Changes in These Responses: There has been a great deal of controversy concerning the relation of vasomotor activity and the galvanic response. The work of Darrow (**2, 3, 4, 5, 7, 8**) in all probability has settled conclusively this particular question. Darrow recorded simultaneously the vasoconstriction of the blood vessels of the skin at the point of attachment of the electrode, the temperature of the skin at this same point, the appearance of sweat as shown under magnification, and the variation of the galvanic skin response. His work showed that this galvanic response appears simultaneously with the secretion of sweat and with alterations in the temperature of the skin. The secretion of sweat was photographed with micro-motion pictures, recording just how the eruptions of the sweat glands occur. The same method demonstrates that the vasoconstriction of the arteries or venules has no one-to-one relationship to the galvanic response. This vasoconstriction may precede, accompany, or follow the initial rise or the peak of the galvanic response. The galvanic response may also occur during vasodilation or when there is no vasomotor change. The photographic records show these points so effectively as to bar further

argument. Darrow (5) has also shown that blood pressure and the galvanic skin response vary independently. The experiments of Bellingham, Langford-Smith and Martin show the same results as those of Darrow, concerning the secretion of sweat.

Richter (1, 2, 5, 8) has made investigations of certain physiological factors which are involved in the electrical resistance of the skin. He reported that the sweat glands control the resistance of the skin of the palms, while the capillaries, epithelial cells and cornified cells play an insignificant rôle. The resistance is greatly decreased when the sweat glands are stimulated to hyperactivity and increased when they are inhibited. The palmar resistance is controlled by nerve impulses. The resistance of the dorsal surface of the hand is dependent primarily upon the epithelial cells and little, if at all, on the sweat glands or capillaries. The conductivity of this area seems to be controlled by local conditions, such as mechanical, thermal, galvanic or chemical stimuli which may be applied directly to the surface. Both the palmar and dorsal resistance changes can be related to the heat regulating mechanisms of the body. The section of the nerve supply of the foot of the monkey leads to an enormous increase in the plantar skin resistance, but has no effect on that of the back of the foot. As was mentioned above, he explained this by holding that the transitory galvanic responses depend upon the sympathetic nervous system, while the permanent levels of resistance of other tissues depend principally upon other factors. Sleep, produced by hypnotics such as paraldehyde, chloral hydrate, amytal, or somnifene, is associated with a large increase in electrical resistance of the skin. This increase is attributed to the effect of the drugs upon the sympathetic nervous system.

Wang and Lu (1) have shown that the galvanic skin response bears a direct relationship to the intensity of the sweat secretion. They have also found that the amplitude of the response is directly determined by the number of sweat glands excited and by the frequency of the activation of these glands. The number of sweat glands excited and the frequency of this excitation are in turn controlled by the number of postganglionic sympathetic nerve fibers conducting nerve impulses to these glands and the frequency of these impulses. Peserico (4) has shown essentially the same physiological mechanisms for the salivary gland. The resistance and capacity of muscle tissue and of the membranes of living cells has been investigated by McClendon (2, 3). He has shown that the resistance of muscle tissue invariably decreases on stimulation. The specific

impedance of the membranes of the erythrocytes at a million and a half cycles per second is about 400 ohms. The impedance of muscle tissue is greater during rest than during stimulation. Fatigue is characterized by a decrease in impedance. McClendon and Hemingway (3) have shown that the interior of the resting cell is electronegative, having an electrical double ionic layer on the surface, since the electronegative interior attracts an abundance of electropositive charges to the outer surface. When the cell is ruptured or stimulated at some point, the electronegative charges are equalized and the double layer is destroyed. To explain the migration of the negative charge they concluded that the cell membrane is usually impermeable and that stimulation causes rupture or an increased porosity of the membrane. The measurements of Telkes and of Gelfan on the amoeba show essentially the same thing.

Continuing the earlier investigations of Gildemeister on the polarization of the skin, Lullies made use of three varieties of electrodes to show the varying polarization phenomena of the skin of the frog to alternating currents. He used a fixed (unaffected by the current) electrode, a changeable electrode in which the capacity and resistance varied, and a changeable electrode with a liquid shunt. By appropriate methods and mathematical analysis of the results he was able to separate the individual parts of the complex reaction of the tissues giving rise to polarization. Hashida has analyzed the same phenomena with NaCl and KCl electrodes, showing that these two chemicals give different results.

Maragaria has shown that the conductivity of living skin is dependent upon the temperature of the skin, although it is not a linear function of the temperature. It is increased by heat and decreased by low temperatures. The relation to the change of the skin temperature is followed by a certain delay in the adjustment of the conductivity. This is not due to vascular irrigation, but more probably to the blood content of the tissue.

Messerle (1, 2), following the earlier study of Minor, investigated the relationship between the galvanic skin response and the electrical output of the heart, pulse, and respiration. He showed that, parallel with the appearance of the galvanic skin response, there is found a decrease in the pulse rate and amplitude of the electrocardiographic waves. The retardation of cardiac action during expiration was due to a lengthening of the P–R or of the T–P wave interval. Studying these same phenomena with skilled rifle marksmen, he found that they never shot during inspiration or expiration, but almost invari-

ably shot during the ascending arm of the pulse wave. From this he concluded that the good marksmen unconsciously allowed for the action of the heart, even though such action never entered their consciousness. Munk and Flockenhaus showed that the electromotive force of the skin is influenced by the drinking of warm or cold water, or by certain physical ailments, such as colds and fevers. They further pointed out that the act of sneezing seems to be a physiological function to restore the electrical potentials of the skin, and thus indirectly affects the skin temperatures. Caster checked the inspiration-expiration ratio and the pulse, as measures of emotion compared to the galvanic response, which he accepted as a reliable criterion of this mental state.

Landis (4, 6) studied the frequency and latency of the appearance of the galvanic skin response together with other personality tests, finding no correlation. Behavior or physiological conditions, which any observer would call grief, anger, suffering, or fear, are not related to the galvanic responses. He concluded that the response, under the conditions of his experiment, represents a local skin reaction of the nature of an internal physiological adjustment which may, but probably does not, have a clearly defined psychological component.

Gildemeister (2) reviewed and summarized the physiological findings for the "*Handbuch der nor. u. path. Physiologie.*" His summary of the anatomical literature is incomplete, being limited to the German literature. However, his comments concerning the physiological research on these phenomena are most enlightening. He stated that there are two points of major physiological interest: (1) What happens in the skin cells during the galvanic response? and (2) What is the functional connection between this response and the autonomic nervous system? With respect to the first point, he showed that there have been three varieties of explanation advanced. The first of these holds that the sweat secretion, which is a result of nervous impulses reaching the sweat glands, leads to the establishment of electrical pathways more easily traversed by the current. The second theory holds that the action currents of the gland parallel the exosomatic current; while the third holds that the polarizability of the tissue is due to the interference with counter-polarizing currents by nervous impulses. The second of these theories is impossible, since several investigators have shown that action currents do not behave in this fashion. The third theory has been elaborated and tested experimentally by Gildemeister and other investigators, par-

ticularly Hōzawa (1). Their results uniformly indicated that such counter-polarization effects did take place. The first of the theories mentioned above is still possible, but there has been no experimental evidence showing that it is true. (Darrow [2] has shown experimentally that this is not true.) With respect to the second major problem, that of the connection of the galvanic response and autonomic action, Gildemeister has shown that many other autonomic reflexes occur simultaneously with the galvanic response as a result of sensory stimulation. Because of the experiments showing that the skin temperature bears such a positive relationship to the galvanic response, he points out that this response is probably part of the general temperature regulating mechanism. Gildemeister gave a very ingenious schematic diagram showing the possible functioning of the permeable membranes of the glands in the galvanic response. McClendon (4) and McClendon and Hemingway (2) have shown experimentally that such a membrane function is possible. Gildemeister also suggested that the adaptation phenomenon, which is so marked in this response, is to be explained in terms of a temperature equilibrium of the skin rather than in terms of fatigue or adaptive mechanisms of the central nervous system.

The Psychological Significance of Galvanic Skin Phenomena

Binswanger was one of the first to formulate the doctrine that the galvanic skin reflex is related solely to affective processes. This particular belief was questioned by Ochorowicz, who somehow had gotten the notion that the doctrine implied that the emotion itself was of an electrical nature and could be shown by the galvanometer. With a great deal of thoroughness he demolished this particular argument but agreed that emotion or affective mental states were concomitants of the galvanic response. More recently, a controversy between Godefroy and Grünbaum has demonstrated the difference in fundamental scientific assumptions which may influence the interpretation of such data. Godefroy had published an article in which he attributed the variability of the electrical properties of the skin to the variations in the emotional life of the individual. Grünbaum questioned Godefroy's assumption. In so doing he reviewed the pertinent literature on the subject and brought together the previous physiological and psychological findings, showing that there was no real evidence indicating that the galvanic response was either a measure of or a criterion of emotion. Godefroy replied by saying that Grünbaum's interpretation was based on the inductive evidence

from the experiments of other individuals and could not be applied to his own work. To the reviewer, it seems that Godefroy's rejoinder and defense were both illogical and not pertinent. Wechsler has avoided such criticisms and arguments by assuming that the psychogalvanic reflex is primarily an index of *subconscious affective reactions*. Such assumptions and proclamations are not uncommon in this field but few have dared state them so explicitly. This assumption permitted him to identify any mental condition which may go with the reflex as affective, whether the person experiencing it was aware of it or not. Such a standpoint, of course, puts the argument out of the realm of scientific discussion.

Wittkower and Fechner have investigated the "psychogalvanic reflex" as a measure of affective psychological experience. They made use of 100 stimulus words in series of 25 each, which were given to 60 subjects whose ages ranged from five to sixty years. These subjects were asked to report their subjective affective experience. It was found that this report and the occurrence or degree of galvanic reaction disagreed practically as often as they agreed. This disagreement they explained on the theory of unconscious emotional life. They held that, (1) the galvanic response and affectivity (unconscious?) were in very close relationship, (2) that the galvanic response was an expression of temperament and character, (3) that the galvanic response was a much more sensitive indicator than was introspection, and (4) that the high affective value of Freudian symbols was demonstrated by this method. They felt that the method would be a valuable diagnostic procedure in psychotherapeutics. They selected 20 of their subjects on which to base a statistical analysis. As might be expected, their statistics showed what they started out to prove. This article is a very good example of an all too frequent type of work which one finds on the psychological aspects of the galvanic response. The authors were convinced that this response had something to do with emotion, and when the introspections disagreed with their experimental findings, they at once concluded that the introspections were wrong. Such articles are scientifically dangerous in that they perpetuate fallacious logic long after those fallacies have been demonstrated.

Linde has reviewed the literature and carried on an investigation of the correlation between these galvanic phenomena and different emotional states, feeling fairly certain that the galvanometric measurements can be related to the subjective evaluations of emotional conditions. The question of whether or not the response is associated

solely with emotion was not considered. The results showed that anger and joy were certainly galvanopositive while dislike and astonishment were probably galvanonegative. No correlation could be established in the case of fright, grief, disgust or curiosity. The reaction to jokes showed that there was a double response: the first being due to expectation and the second to the understanding of the joke. Wechsler and Jones (1, 2), in investigating the difference between the individual threshold for fear and for anger, used a correlational analysis of the degree of deflection, finding that the *corrected* correlations showed a high degree of specificity between the response and these two emotional conditions.

During the past three years several studies have been published from the University of Iowa, making use of the galvanometric technique. Bayley investigated fear by this method. She found that the most intense response occurred following stimuli which she described as startle, shock or alarm. She also found a gradual change in resistance (rest current?) which was affected by the state of apprehension or of ease which was being experienced by the subject. Apprehension caused a general decrease in resistance, while ease led to an increase. As a result of her study, she concluded that there were two kinds of fear—startle and apprehension. Her study was followed by that of Patterson, who investigated the "emotion of surprise." She did not find objective basis for differentiating surprise from fear or startle, although it could be partially differentiated from apprehension. A qualitative analysis of the surprise experience indicated that it consisted more largely of ideational factors and of fewer organic components than did startle or fear. Ruckmick (2) stated that the galvanic reflex, when properly safeguarded, was a promising approach to the analysis of the emotional life. He stated that the more primitive and instinctive emotions show the greatest deflection. To the reviewer it seems that the findings of Bayley, Patterson and Ruckmick are partly explicable in terms of muscular tensions which give rise to increased skin temperatures and perspiration, and that there is no special need for reference to classical psychological categories. The findings of Smith, who worked in the Iowa laboratory, are in a sense a check on part of the enthusiasm of the other Iowa reports. Smith found quite a few "spontaneous reflexes" during the waiting period before the experiment. He likewise found great individual variations in the magnitude of the reflex and between the amount of deflection given for the same subject at different times.

Bujas (2), in a study with *one* subject, showed that the positive

or negative deflection of the galvanometer corresponded to the quantitative introspection of that subject with relation to the emotional experience. He added, "Further investigations confirmed this result—so much so that one can establish a psychogalvanic law. In another subject, who was depressed, the regularity was altered by the unpleasure entering into the reaction. In the case of pleasure the current is from the right hand to the left, for displeasure, *vice versa*." He further stated that the response might be voluntarily suppressed by taking an indifferent attitude; that it was a specific phenomenon of emotion; that it showed the quality of the emotion by the direction of the effect, while the intensity of the emotion was shown by the magnitude and the temporal duration by the duration of the response. Since all subjects did not react to the same degree, one could therefore measure individual differences in emotivity. These remarkable findings were expressed in general terms without specific tables or description of exact technique, etc. Bellingham, Langford-Smith and Martin held to the point of view that the galvanic response did not register all emotion, for in an "obstructed" situation with an attempted reversal of volition, the facial and bodily movements which were expressive of stirred-up mental conditions, were more pronounced than either the association test responses or the degree of the galvanic response. Generally speaking, these authors felt that the galvanic response was usually associated with emotion. Banerjee held that in most cases the affective states were accompanied by galvanic deflections, although this association was not invariable.

Jones (3), studying infants, found that a marked galvanic reaction occurred on the first presentation of a bell, buzzer or loud clang, while the overt reactions of the infant to such stimuli were less consistent. In several cases overt startle reactions to loud sounds were never shown, except when the infant was dropping asleep. The galvanic response was obtained when the bottle was withdrawn during nursing or when there was a sudden withdrawal of support. It was never elicited by visual stimuli (except after conditioning), by conditions involving relief nor by any form of stimuli which would be ordinarily described as pleasant.

Misbach and Davis (5) have each investigated the effect of auditory stimulation upon skin resistance. Davis made use of noise, while Misbach used tone stimuli. Davis (5) showed that loud noises cause a sudden drop in the skin resistance. The deflections were analyzed into two components; the first of which was attributed to the physical effects and general stimulation, the second to restless-

ness. He found large individual differences in these responses. Misbach reported that brief tone stimuli of relative pureness evoked a significant number of blood pressure, pulse rate and galvanic responses, even if shock and expectation of pain were eliminated. Galvanic responses to tones of a frequency higher than 512 d.v.s. occurred more often and increased in average magnitude as the frequency became higher. Judgment of equal loudness of tones was not a measure of their disturbing power, as indicated by the galvanic response.

The applications of the galvanic phenomena in psychiatry will be discussed below, but several of the papers which have certain psychological significance will be considered here. Syz held that the emotional life of the schizophrenic patient was reflected by his galvanic responses. The variations in the electrical resistance of various psychopathic groups were so different that he held that the emotional life and mental status of such patients could be interpreted in these terms. Westburgh (1) assumed that the galvanic response was either directly or indirectly related to affective response and that it offered the most promising method of the investigation of emotion. Certain mental states or conditions were shown diagnostically by the use of the galvanometer; tension and anticipation appeared to be factors only in so far as they induced affective states. This latter statement was in contradiction to the work from the Iowa laboratory cited above. Ödegaard used the galvanic response to determine the general vegetative emotional reactivity. He regarded the method, not as a series of special tests, but as one single test for the determination of emotional reactivity in general. The more serious psychopathic conditions showed the most atypical galvanic activity. The organic and schizophrenic conditions showed the greatest degrees of reactivity; constitutional, manic and hysteric conditions showed the most instability; while depression showed atypical reactions when anxiety or agitation entered into the clinical picture.

Holding that both changes in blood pressure and in the galvanic response were indications of the presence of emotional states, Rackley stated that fear producing stimuli caused greater changes in blood pressure and in the galvanic response than did mental work. Porter and Copeland stated that the galvanic measures of emotional response showed an increase in reliability between the ages of eleven and seventeen. Younger subjects gave weaker responses to association stimulus words than did older. They also believed that in a college group the women showed more marked galvanic responses than did

the men. They related their findings to the differences in the development of the emotional life of the sexes. Talenti used the galvanic response as a method of testing the psychological reactions of aspirants for flying courses at an aviation school. He failed to find a correlation between the degree of emotional stability, as judged by the methods usually used at the school, and those obtained on the basis of the galvanic responses. He also failed to establish any close relationship between intensity of the response and the degree of actual emotion subjectively experienced and reported by the subject. He concluded that from his findings it was evident that the stimulus must be elaborated in the consciousness of the subject, and that the psychic action aroused by this elaboration must have an emotional content before the galvanic response appeared. The intensity of the response depended, therefore, upon the mental image which was provoked by the stimulus. Mathews, in describing one of Waller's demonstrations of these phenomena, pointed out that the method was a good one for the investigation of emotion.

Sears made a study of the galvanic skin response, together with facial grimaces, reflex withdrawal of the leg, respiration, and pulse activity, brought about by pressing a needle against the side of the leg. He was interested in deciding the efficiency of each of these as measurements of disturbance under both normal conditions and with the anesthesia of the stimulated area suggested in deep hypnosis. The results indicated that facial flinch and the increased variability in respiration were practically eliminated by the suggested anesthesia, while the variability in the pulse tracing was reduced. The galvanic skin response showed a reduction of 20 per cent on the anesthetic leg. A series of stimulations given to the normal subject, who was instructed to inhibit his reactions to pain when the left leg was stimulated, showed that none of these reactions were modified to any marked extent. It seemed then that hypnotic anesthesia is certainly distinct from the voluntary inhibition of reaction to pain. Sears' comment that the galvanic skin response is completely non-voluntary, is open to question, since several writers have pointed out instances in which this response has been obtained voluntarily.

Feasey attempted to use the galvanic response as a measure of the emotional reactions in esthetic judgments. The results were ambiguous, and although the response might be of some diagnostic value, it was not felt that it was suitable for exact psychological investigation in this field. Phares investigated the galvanic response in relation to musical appreciation. She found that it did not differentiate emotions

qualitatively, although the amplitude of the response gave some indication of the degree of affective tone experienced.

Assuming that the galvanic response was a measure of emotional reactivity, Wechsler, Crabbs and Freeman (1, 2) have made use of the method in a study of preschool children. Their results showed a positive but small and unreliable correlation between the galvanic response and other criteria, such as ratings with regard to specific or general emotional tendencies. Exceptions to this general finding were found in the items, depression and instability, which gave coefficients of +0.35 to +0.65 with several criteria. The galvanic response of the girls was uniformly greater than that with the boys. No age differences appeared within the group measured. Correlations between the effectiveness of successive batteries of stimuli, given at intervals of 2 to 6 weeks, were +0.55 to +0.75. The most effective stimuli were loud noises and tipping; the least effective were verbal stimuli. Thouless (2) stated that the galvanic response may be used as a method of making a rapid survey of the kind of thing to which a person will react emotionally. He also stated that the work with this response indicated that emotional changes are much more frequent than it is commonly supposed. Brun studied the effect of the presentation of pictures, certain of which were of an erotic nature, to normal and pathological individuals, who were experimentally subjected to the influence of alcohol or bromide. He practically assumed that the galvanic response was an adequate indicator or measure of emotion, and on this basis he interpreted the effect of these drugs upon various types of subjects. It is of interest to note that alcoholic intoxication always decreased the galvanic response and that the galvanic reactions to erotic stimuli were reduced further during the intoxication than were the reactions to indifferent stimuli. This, he said, argued for the assumption that the increase of sexual interest after indulgence in alcohol is only apparent and is due to the disappearance of inhibition. He concluded that the galvanic response could give us no solution or explanation of the nature of emotion and, therefore, could not be considered as an independent method for the determination of psychological facts.

Lauer (2) made a study of the reliability of the galvanic response with respect to repeated tests. He found that its reliability was quite high, indeed higher than paper and pencil tests of emotionality commonly used in psychological laboratories. He did not take up the psychological significance of the response. Estabrooks (1) has investigated the galvanic response as a measure or criterion of suggesti-

bility. He found that the amount of electrical resistance correlated +0.34 and +0.38 with two other measures of suggestibility which he employed. He stated, however, that these positive relationships were probably due to some peculiarity, either in the tests used or in the subjects employed.

Darrow (5, 6) has reviewed the literature, bearing on the differences in physiological reactions to sensory and to ideational stimuli; and, using the electrical and circulatory responses, he has investigated these differences experimentally. He shows that sensory stimuli occasion larger galvanic and smaller blood pressure changes than do disturbing ideational stimuli and, conversely, disturbing ideational stimuli give rise to larger blood pressure changes and smaller galvanic changes than do sensory stimuli or indifferent ideational stimuli. Certain of these changes probably are to be explained by differences in respiratory reactions. He concluded that there are two physiologically as well as psychologically distinguishable processes which frequently have been designated as emotion: the immediate reflex response to sensory excitation, and the response mediated by associative processes or ideas aroused by a stimulus. Shock or surprise with its attendant galvanic reaction is probably occasioned by the irradiation of excitation due to a momentary lack of neural organization leading to the appropriate responses. Blood pressure changes, under the conditions of his experiments, differentiated more between disturbing and indifferent ideational stimuli than did the galvanic response. Darrow (9) has further shown that the recovery curve of the galvanic reaction is of more significance than any other portion of the reaction. He reported that the recovery-reaction quotient is accentuated by the effect of such psychological categories as mental tension or anxiety, which enhance reaction and retard recovery. He obtained some correlation with certain "neurotic" symptoms.

Crosland, and Crosland and Beck have reported a study of the correlation between reaction time in an association test and the galvanic response obtained by the use of the Hathaway apparatus. He used fifty-five male subjects in one series and forty-one in another; he used association words, certain of which were markedly sexual in nature. He made two readings on the galvanometer for each reaction, (1) the absolute or maximum excursion, and (2) the difference between the starting point and the final termination, *i.e.*, the relative excursion. These readings were found to have an odd-even reliability correlation of +0.97. Individuals varied widely in

the size of the relative galvanic deflections. There was practically no correlation between reaction time and the relative galvanic deflection, which is in contradiction to the +0.60 found by Hathaway (2). Crosland criticizes the view of Landis (5), which holds that the galvanic reaction is not associated with emotion, saying that Landis' criticism is merely academic. Crosland maintains that the entire duty of the psychologist is to find and measure coincidence and correlation and then to make predictions from such data. This is all very well, for certainly Crosland shows what has been public knowledge since 1907, namely, that certain words in an association test are accompanied by marked galvanic reactions. He does not demonstrate that these words necessarily have anything to do with emotion. He merely proclaims the fact that they are emotional, and then assumes that everyone else should agree with him. Whether or not these words had an emotional significance for the subject, or whether Crosland made any objective measurement of emotion certainly is not demonstrated by this particular research.

The authors thus far considered, with the exception of Darrow, either have convinced themselves or assumed that the galvanic response is somehow associated primarily with emotion, emotional reactions or affective consciousness. Aveling has for some time maintained that this galvanic reaction is not affective in nature, but is associated with conation. His position was summarized in his address at the IX International Congress of Psychology. His reasoning was as follows: Most of the work on the response has been based upon the observation of mental phenomena as large entities, and the galvanic phenomenon has been assigned to the emotional state without further analysis. As a matter of fact, it has been common knowledge that the response may occur in the absence of introspectable emotion, and that the time elements in the sequence of events have not been adequately considered. During the latent period of response, perception of the adjustment and of the attitude have occurred, but it has never yet been shown that anything in the nature of emotion occurred during this time. Experimental work of his own showed that this response occurred commonly with introspectively reported states of alertness. He also found that the percentage of increase or decrease in resistance correlated highly with the introspectively reported process of conation. In another experiment on judgment it was shown that the reflex was correlated with conation and, indeed, anything of the nature of felt emotion was rarely reported, although the galvanic response appeared regularly. From

Aveling's remarks one concludes that conation for him represents almost any variety of mental or cerebral activity above the level of sensation. Cattell (1, 2, 3) has investigated these phenomena from the standpoint of the distinction between affection and conation, and concluded that the response is in the main associated with conation. The fact that the response is associated more often with unpleasant feelings and emotions than with pleasant ones is, Cattell believed, an additional support for the conative interpretation, since unpleasant feeling is almost invariably associated with ensuing conation. Messer is said to have found that active conative processes gave a greater deflection than did purely emotional experiences. Messerle (2) has shown that the galvanic response is closely associated with periods of extremely high degrees of attention. Weinberg (3) has related the galvanic response to the raising of the level of consciousness, which was accompanied by an increase in the catabolic processes of the body. Abramowski (1) held, as a result of a series of experiments, that the galvanic response was largely under control of the will and could be used as a method of demonstrating volitional processes. Buytendijk and Eerelman stated that the response was not a direct expression of an emotional state, but rather of an initial cerebral action determined by the intensity or form (*Gestalt*) of the stimulus.

During the past four years several carefully planned experiments have been conducted to attempt to establish the psychological correlate of the galvanic response. Experiments by Abel, which were done with very careful and valid introspective procedures, led her to the following conclusions: "Our experiments have not substantiated the widespread belief that the galvanic skin reflex is an indicator of some general psychological class, as of emotions, conations or volitions. Most of the experimental work designed to support such a belief has been too gross and too conceptual to merit credence. On the positive side, our study seems to point to a fairly definite functional connection between electrical changes in the skin and certain reportable attitudes (*Bewusstseinslagen*) which mark sudden, decided and momentary checks in the course of the comprehension and the solution of simple problems of an elaborative sort." These conclusions are to be compared to those of Linde and of Cattell, which were given above.

Gregor (2), Wang, and Landis (5), on the basis of investigations of the work of many previous experimenters, have arrived at conclusions concerning the psychological nature of the phenomenon

which are not in harmony with much of the work which has been cited above. Wang reviewed the present knowledge in this field, discussed the psychological theories of the galvanic skin reflex and summarized his conclusions by stating that, "The galvanic skin reflex is one of a complex of autonomical reflexes which are closely bound to muscular activity, and which have the sole function of rendering the muscular activity more efficient, either directly or indirectly." His résumé of the psychological significance of these phenomena led him to conclude that nothing could be gained from this approach to the problem. Only when these phenomena have been investigated physiologically and neurologically can we understand their significance and possible psychological applications. Gregor (**2**), in his survey of the literature, showed the tremendous amount of contradiction which was found between the investigations reported by the numerous authors regarding the psychological significance of the response. He left the question without conclusion, allowing the review to speak for itself. Landis (**2, 5**) reviewed the literature bearing on the psychological significance of this phenomenon, and concluded that there is no reason to believe that this response is a measure of, regular criterion of, or indication of any one or any combination of the traditional psychological categories. He agrees with Wang that the phenomena must be interpreted in terms of their physiological significance. Landis (**4, 6**) obtained records of the galvanic skin response while the subjects were working on a difficult pursuitmeter. Certain of these subjects showed overt activity, which would be called grief, anger, suffering, fear, etc., by any observer. In those cases in which these expressive emotional reactions did occur, it was found that the response did not appear nearly as frequently as it did under ordinary circumstances. There was no evidence that the appearance of the response could be correlated with any psychological event.

From this literature, giving the results and conclusions of many investigators, the reviewer is convinced that there is really no adequate evidence that these electrical phenomena of the skin are of necessity associated with any psychological event. They are, as Wang pointed out, strictly physiological in nature and probably have a marked and important psychobiological significance. There is really no justification for anyone using any present galvanometric technique or method as a measure of, or a criterion of any of the traditional psychological categories, personality traits, or social relationships of the individual.

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Bourguignon, in a study on chronaxie which is only indirectly connected with the phenomena of skin electricity, claimed that the chronaxie of the vestibular nerve furnished a direct measure of the degree of emotivity, when normal states are compared to pathological mental conditions; and even in some cases it provided a direct measure of the emotional experience of the normal subject at any given time. If this astounding claim can be substantiated, it will furnish a marvelous psychological measuring device. However, one suspects, on the basis of the published results, that it is no better founded in fact than was Féré's claim in 1888 that emotion was measured in terms of the static charge of electricity carried on the surface of the body.

Applications

The phenomena of electrical variations of the human skin were first brought to scientific attention by neurologists and psychiatrists. It is only natural that the most frequent application of these methods to practical problems is found in the field of psychiatry and of clinical diagnosis. Much of the work on this aspect of the subject was considered in the review of Landis and DeWick. More recently Landis (7) has brought together the literature showing the relationship between psychiatry and the galvanic skin response. His tabulations showed that with respect to dementia praecox, hysteria, hysterical anesthesia, neurasthenia, amentia, and alcoholic insanity, no relationship can be established. The finding of any particular investigator could be matched by the findings of another who made opposite claims. With respect to catatonia and to manic-depressive insanity, the results were fairly uniform, showing a decreased psychogalvanic reactivity. These findings are understandable in view of the physiological analysis given above.

The more recent findings may for convenience be briefly stated: Syz found increased psychogalvanic activity in dementia praecox. Westburgh (2), Ödegaard, and Syz and Kinder (2) found decreased activity. Syz, Richter, Syz and Kinder (1, 2), and Westburgh (2) reported decreased electrical resistance of the body in this syndrome. With respect to catatonia, Syz, Westburgh (2), Ödegaard, and Syz and Kinder (2) reported decreased galvanic activity, while Richter (1), Syz, Syz and Kinder (1, 2), Westburgh (2), and Westburgh and Eyman reported increased electrical resistance in the body. Ödegaard, and Richter (1) reported that the galvanic activity in hysteria was the same as in the normal, while Myasishchev (1, 2) reported that the galvanic reactivity in hysterical

anesthesia was the same as in the normal. For manic-depressive insanity Syz, Westburgh (2), and Syz and Kinder (2) reported decreased galvanic activity, while Ödegaard reported an increased variability in this activity. With respect to the electrical resistance of the body in this syndrome Syz, and Syz and Kinder (1, 2) reported an increase, while Richter reported that the resistance was the same as normal.

Clinical Applications: As has been mentioned above, Feasey and Flemming have used the galvanic response in attempts to determine the emotional elements entering into aesthetic appreciation. Collman and McRae have used this method to study the strength of the various instincts. They selected words supposedly associated with the instincts and obtained a correlation between the degree of deflection of the galvanometer and rating scale judgment of instinct strength of +0.43. Talenti used the method to investigate the emotional stability of candidates for training in aviation. Wechsler, Crabbs and Freeman (1, 2) have made use of this method to investigate the emotional reactions and emotional development of preschool children. Gelma, stating that the response is an objective indicator of emotion, made use of the procedure in the examination of several criminal offenders. His results indicated that these suspects reacted strongly to association words connected with legal procedures.

Grassheim, Lueg, and Lueg and Grassheim (1, 2) have investigated the clinical use of measurements of polarization capacity as indicators of disturbance in thyroid function or in metabolism. They have shown that in thyroid diseases there is approximately 90 per cent agreement between the polarization capacity and the clinical diagnosis. They believed that this is more accurate than is the usual determination by basal metabolism. In adipose cases extraordinarily varied measurements were obtained, which they believed to be an indication that the adipose disturbance is one involving the entire endocrine system. It seems possible that this method may be of marked clinical significance, particularly since the polarization capacity seems to be related solely to thyroid function. Roggenbau and Lueg (1, 2) have made a study of the polarization capacity in psychotic conditions. Their results were not reported in detail, but were presented as a suggested technique or a method of measuring the glandular influences in psychotic states.

Regelsberger (4, 5, 6) used the disturbances in the diurnal variations of the polarization capacity of the skin as a method of investigating changes in the metabolic status of the body. His extremely

interesting and suggestive results showed that these electrical changes are a reflection of certain metabolic processes under certain conditions, but that the method is not yet available as a gross measure of any particular physiological function.

Purdy and Sheard, and Purdy, Johnson and Sheard have made use of measurements of skin potential as a means of determining basal metabolism. They pointed out that the skin potential could not be used in thyroid disturbances. This is in contrast to the work of the Germans, indicating that polarization capacity (not potentials) finds its greatest use in thyroid dysfunction. Petersen and Levenson showed that the skin resistance, following the use of some skin irritant, was disturbed in individuals suffering from tuberculosis or exophthalmic goiter.

Wiersma (1, 2) used the galvanic response to investigate the emotional or intellectual status of clinical patients. His reports are of the general clinical variety and give little accurate or helpful detail. For the most part his suggestions are of the variety which have been shown to be fallacious by previous investigators.

Tchootchmareff, in the English abstract of a Russian monograph on the effect of work upon the nervous system, reported that the galvanometric phenomenon is a useful method in the investigation of temperament and of the psycho-physiological forms of behavior. Under temperament he indicated that the innate power and quickness of motor reaction was shown by the form of the primary deflection of the galvanometer curve. He found insignificant deflections in hysterical patients and very marked deflections in Basedow's and Parkinson's diseases. The quality of the galvanometer deflection was influenced by the state of fatigue of the worker. He stated that this indicated the effect of fatigue upon the mental life and attitude of workers.

Individual Differences: Cattell collected a large number of galvanic records together with detailed introspections in an attempt to ascertain the extent of the galvanometric deflection associated with specific varieties of conscious processes. He found a great range of individual differences in the deflections. Each subject was found to have atypical curve shapes under certain conditions and that the curve shapes of all subjects responded in the same general way to the changes in mood and subjective conditions. Linde reported that introverts showed a tendency to give rather smooth, swinging galvanic curves, while extroverts gave sharp, peaked curves. Feokistova is reported to have found that relationships existed between person-

ality and certain characteristics of the galvanic response, while Myasishchev (1) is reported to have found marked differences in the galvanic responses between various types of individuals. Weiss and Lauer used the psychogalvanic responses in a study of differences between the persons who were safe automobile drivers and those who had a record of several accidents as automobile drivers. They found that the "accident" group showed a consistently greater intensity of response to sensory stimuli when compared to the "safe" group. Individual differences in the galvanic response, which are said to exist between people of different temperament or of different physical strength, have been reported by Tchootchmareff.

Crosland and Beck found marked individual differences in the reactions of different subjects to an association test. These reactions, although statistically reliable for the galvanometer deflections themselves, were not related to the reaction times or the responses in the subjects. Roggenbau and Lueg (2) showed that there were marked individual variations and differences in the polarization capacity of the skin between the various psychotic groupings and normal individuals. Lauer and Evans made a study of the amount of galvanometric deflection, heart changes and respiratory changes evoked by mild emotional stimuli. These results were correlated with scholastic grades and with scores on an intelligence test. They found a correlation as high as —0.42 between intelligence and bodily resistance. No other of their correlational figures seemed to be of any particular significance. In general, they reported that there was no significant correlation between success in college and emotional stability, if emotional stability was measured by the type of records which they obtained.

The differences which have been shown to exist in the frequency of the appearance of these phenomena when related to the sex of the subject has been attributed to the supposed greater emotionality of women. From the physiological viewpoint it seems that it would be more rational to explain this difference on the basis of the higher metabolic rate of women. That is to say, individuals showing higher metabolism and higher skin temperatures will exhibit the galvanic response more frequently.

Association Experiments: The use of the galvanic response in association experiments was started by Veraguth and Binswanger in 1907, and has been a favorite method of investigators ever since. Abramowski (2) in a study of the individual types of serial association found that the word given in the sequence was not a matter of

chance but was determined by the essential psycho-physiological properties of the individual. By investigating the relationship between these responses and the galvanic response, he felt that he was able to obtain insight concerning the central core of ideas from which the various associations sprang. Bellingham, Langford-Smith and Martin, in an investigation of reaction time and galvanic responses, found that the "set" of the individual was basic to the response. They interpreted their results as indicating that deflections which occurred were due to chance association and not to any effort of imagery or of choice. Wechsler and Jones (1) repeated in part the experiment of W. W. Smith, using the 16 words of Smith's list, which Smith had found to have either the highest or the lowest valuation in terms of deflection. They found that the words which gave the greatest deflection for Smith also gave them similar results. In 13 out of 16 cases the greater deflection was elicited when the word was at the first rather than at the end of the list. Hence, in evaluating the galvanic response in the association experiment, the position of the word in the series must be considered and given weight. Jones and Wechsler further reported that critical and non-critical words could not be distinguished unless buffered by five neutral words. Porter and Copeland studied galvanic response and reaction time with a group of subjects between the ages of eleven and seventeen. The association reaction times appeared to increase gradually with age. Hathaway (1) used the association experiment together with the galvanic reactivity to investigate an epidemic of stealing in a college dormitory. He found that the galvanic response was more accurate than was reaction time when used in this way.

Crosland, and Crosland and Beck have made use of the galvanic response and reaction time measurements to association words to make what they termed an objective measurement of emotion. As has been pointed out previously, their general findings showed little that was new or different, except the statistical reliability of certain measurements. Westburgh and Eyman used the galvanic response in connection with association words in a measurement of the "affective responses" of manic-depressive and dementia praecox patients. They concluded that the absolute deflection to words of any particular type was not important, but that the deflection, when compared to deflections given to other types of words by the same individual, might be developed by further study to a point of indication of the etiological factors operating in the psychotic individual.

Dysinger exhibited association words visually, recorded the galvanic response, and had each of 13 subjects rate each word shown

as pleasant or unpleasant on a five point scale. He reported that in 25 out of 37 cases, the magnitude of the deflection was indicative of the degree of affect experienced by the subject. This experiment has been conducted so frequently and with such a variety of results that little importance can be attached to the results. It would be interesting to have this experiment carried through on a large group after the experiment had been arranged to care for the many sources of error pointed out by the previous investigators.

Conditioned Reflex: H. E. Jones (1) first reported work showing that it was possible to condition the galvanic response in infants over four months of age. Previously, indifferent stimuli were associated with faradic stimulation. The galvanic response to the substitute stimulus was elicited after four to fourteen such associations. Repetition of the substitute stimulus alone usually resulted in a quick exhaustion of the response which would appear the next day without further conditioning. This conditioning was shown to last four weeks in one case and six weeks in another after the unconditioned stimulation had been removed. M. C. Jones reported on this same work. Slight was able to condition the galvanic response in adults. An interesting confirmation of his findings occurred when one of the subjects, whom he had been unable to condition to red and green lights, was found to be color blind. Freeman established a conditioned galvanic response in two university students.

The Russian reflexologists during the past two years have reported several studies using the galvanic response in conditioned reflex experiments. Sorokhtina-Minut reported that, after the associative reflex has been established in some subjects with predominating inhibitory processes, they ceased to respond for a period of time. This particular experiment was an attempt to study these inhibitory phenomena and to derive methods for controlling them. Physiological analysis of the results lead the author to the conclusion that the basis of the observed phenomena lies in the fact that the light signal, instead of acting as an associative excitant, becomes an associative inhibitory. Myasishchev (1, 2) is reported to have found that the galvanic response was easily conditioned and may be used to investigate the formation, differentiation, intensity, permanence, etc., of the conditioned response. He particularly studied the response with hysterical patients. Fluctuations in the results were found to depend upon the different types of patients used and the degrees of their disorder. Ischlondsky (1, 2) reported that he had conditioned the galvanic response with strong acoustic or pain stimuli to an indifferent light stimulus, which soon became effective.

The experiments were conducted on both human subjects and on frogs. They were not very successful with dogs or cats. He found that the variability of the galvanic response was quite troublesome. It did not give consistent results and the inconsistency did not yield to his attempts at control.

The Galvanic Response Compared to Other Types of Psychological Measurement: A. Associative Reaction Time: Reaction time has been measured and correlated with the galvanic response by Hathaway (1, 2), Porter, Porter and Copeland, and Collman and McRae. Hathaway reported a correlation of +0.60 between reaction time and the galvanic response in the association experiment. Porter and Copeland reached essentially the same results. Collman and McRae obtained a correlation of +0.43. Crosland and Beck have criticized severely the work of Hathaway in this connection. They held that there was practically no correlation between reaction time and the relative galvanic response.

B. Pulse: The relation between the galvanic response and pulse rate has been studied by Caster, Messerle (1, 2) and Blatz. Caster reported that the galvanic response was a more accurate check of strong stimuli than was the pulse rate. Blatz showed a close correlation between the variations in the pulse rate, cardiac activity and the galvanic response. Messerle found that the galvanic curve paralleled curves of pulse rate.

C. Respiration: The same investigators who have been listed under "Pulse" also investigated the relationship of the galvanic response to respiration, and showed, in general, that the phases of the respiratory activity were closely correlated with the galvanic response. Syz (1) found that in catatonics the respiration curves were not closely allied with the galvanic curves.

D. Secretion of Sweat: Kuno and Ikeuchi studied the rate of perspiration of various areas of the human skin. Their study was made by measuring the amount of perspiration from areas of about 20 sq. cm., which were covered by a small disc through which was passed for five minutes a measured current of dried air. The moisture picked up in this way was absorbed chemically and weighed. The temperature of the same area together with the rectal temperature was measured simultaneously by thermocouples. Measurements were made of the forehead, cheek, neck, chest, abdomen, back, lumbar region, armpit, inside and outside of upper arm, forearm, palm, thigh, leg and the sole of the foot. They found that the surface of the body, on the basis of secretion, could be divided into four different sorts of areas: (a) palm and sole, which secrete 4 to 10 mg. per five

minutes per 20 sq. cm.; (b) face and neck, 3 to 8 mg.; (c) extremities, 1.2 to 2.3 mg.; and (d) trunk, 0.7 to 1.9 mg. They found no relationship between the rate of sweat secretion and the skin temperature. Interestingly, they found that when the rate of secretion of sweat of other parts of the body was increased by an increased atmospheric temperature, the rate was decreased on the palms and soles. Also they found no relationship between the rate of secretion of the palms and of the soles.

In the light of this experiment the work of Darrow (2, 6) and Richter (5), which showed that the secretion of sweat and the galvanic response were very closely allied, is not as final as one might wish. The variation between the results obtained by Landis (1) and those reported in the earlier papers of Richter is now more understandable. Richter's measurements were made on the palms while those of Landis were made on the area between the toes, and the areas are not comparable in their reactions as the work of Kuno and Ikeuchi showed. The discrepancies between the temperature determinations of Landis (1) and of Darrow (2, 4) can also be explained by the fact that Darrow was working with the galvanic response while Landis was determining apparent resistance of the skin. The discrepancy in these results deserves a further investigation. Such an investigation should be thoroughly and carefully carried out, since theoretical basis of the relationship between skin potentials, resistances, or capacities and basal metabolic rate or skin temperature is based on this type of experimental finding.

Wiersma (2) reported that measuring the skin temperature, sweat secretion, and galvanic response simultaneously demonstrated that they have practically coincident records. His report is a rather generalized statement, and no details are given so that it is impossible to evaluate his statements.

E. Temperature: Darrow (2, 4) has shown by very careful work that the variations in the temperature of the surface of the skin at the point of attachment of the electrodes are very closely allied, if not uniformly a part of the galvanic response. Richter (5) related the skin temperature to the changes in skin resistance.

F. Vasomotor Changes: Darrow (2, 3, 6, 7) has shown that vasoconstriction and vasodilation are not allied to the galvanic response in any fashion which indicates a necessary correlation between them. McClendon and Hemingway (3) stated that the contraction of the blood capillaries is a reaction following a nervous impulse which travels along the same general sympathetic pathways as the impulse to the sweat glands. Wang, Pan and Lu reported that

there is no relation between the galvanic response and vasoconstriction, since the latter is unaffected when the hind-brain is destroyed. Weinberg (1, 2, 3) held that the changes in blood volume are associated with the same general electrical phenomena but are not necessarily causally connected with them. Wiersma (1) showed that in hysteria the plethysmographic curve does not alter when the galvanic response occurs.

G. Blood Pressure: Darrow (1, 5) has shown that ideational stimuli are more effective in producing changes in blood pressure than are sensory stimuli, while the case is reversed with respect to the galvanic response. He also showed that the blood pressure and galvanic skin response vary independently. Rackley reported that there is a positive relationship between blood pressure changes and galvanic responses, but this relationship is not great. Misbach investigated the changes in blood pressure and in galvanic response to tone stimuli of different pitches. He made little of the blood pressure measurements.

H. Electrocardiogram: The changes in the electrocardiogram and the galvanic response were first reported by Blatz who drew no conclusions as to the relationship. Messerle (1, 2) showed that the variations in the electrocardiogram paralleled those in the galvanic response, although he did not suggest a causal relationship. Weinberg (1, 2, 3) came to essentially the same conclusions as Messerle.

I. Basal Metabolic Rate: Purdy, Johnson and Sheard, Purdy and Sheard, and Sheard have been investigating the relationship between basal metabolic rate and the electrical potential of the skin. They reported that, if there were no dysfunctions in the circulation of the skin, the metabolic rate may be calculated, within ± 4 points, from the formula $x = \frac{\log y - \log 0.005}{-0.0396}$ where x is the metabolic rate and y is the difference in millivolts between areas 12 cm. apart on the back of the forearm. They reported that day by day variations, emotional effects, and the partaking of food have less effect on the electrical potential across this area of skin than they had on the metabolic rate. They reported an inverse correlation between the cutaneous temperature and these differences in electrical potential. The results were interpreted on the basis of a relationship between the electrical potential and the circulation of the blood rather than on a direct relationship to metabolism. The circulation must be maintained constant before the correlation between metabolism and the electrical potentials can be found.

The experiments of Lueg and Grassheim (1) and Grassheim

showed that in diseased conditions of the thyroid the rise and fall of the polarization capacity of the skin and basal metabolism paralleled each other. This parallelism was found in about 90 per cent of the cases. They believed that the skin capacity was superior to metabolic studies for the investigation of toxic thyroid conditions. Regelsberger (**5, 6**) reported results which are greatly similar to those of Lueg. He, however, has investigated the physiological basis of this phenomenon in greater detail and concludes that it is an open question whether the influence of the thyroid gland upon the polarization capacity of the skin is direct or whether it is simply a single factor in determining the shape of the curves obtained. He points out that the diurnal variation in these measurements takes place independently of variation in metabolism when the metabolism is artificially affected. The variations, he believes, are most probably due to the same regulatory mechanism controlling the body temperature. It is quite evident that under certain conditions, which have not as yet been experimentally specified, a close relationship does exist between metabolism, temperature, and certain electrical properties of the skin. The point is of major physiological and psychological interest, since, if we can set up standard conditions for such measurements, we will have a new method of investigating vital activity. At present the field is in a confused state, but certainly further careful research will provide such measures as are of value and importance.

J. Muscular Tension: White has shown that there is a higher electrical resistance in relaxation than in tension but that in only one of his subjects was the electrical resistance greater during mental multiplication than during general relaxation. Keller (**3**) has shown that physical exercise gave rise to potential differences of the skin.

K. Fatigue: Strauss (**1, 2**) measured the differences in potential between the mucous surface of the lip and the palm of the hand before and after strenuous exercise. He believed that the change in potential which took place during and immediately after the exercise was a result of the fatigue, and that the rate of return to normal was a measure of the degree of fatigue experienced. The method is an interesting one and deserves further attention.

The work of Ueno, in Japan, and of Tchootchmareff, in Russia, represents attempts which have been made to measure industrial fatigue in terms of the galvanic response or in terms of variations in bodily electrical resistance. As far as one can judge from the English abstracts of these papers, the results are not conclusive. The authors are in each case very hopeful of the method and state that in certain cases it works very well. The results of Strauss are much

more definite and were better controlled than those of either Ueno or Tchootchmareff.

Miscellaneous

Hypnosis and the Galvanic Response: Estabrooks (1, 2) has used galvanic response as a measure of suggestibility and as a method of measuring the depth of the hypnosis. He found a correlation of about +0.35 between the decrease in resistance and certain tests of suggestibility. He further reported that in hypnosis, as in sleep, the gross resistance tended very definitely to increase. This increase constituted an objective measurement of the depth of hypnosis. Levine, using Richter's methods for measurement of electrical skin resistance, reported that hypnosis did not materially alter the electrical skin resistance, either when that resistance was originally within normal limits or when it was beyond those limits. He stated that skin resistance could not be used as a criterion of the presence or depth of hypnosis. The palmar electrical resistance was an index of the presence or absence of responsiveness rather than of gross muscular tension or relaxation. The results of Levine are in direct contradiction to those of Estabrooks and of White. Myasishchev (2) is reported to have found that in hypnotic hyperesthesia the galvanic reactivity is intensified.

Sears, in a study of hypnotic anesthesia, showed that the amount of galvanic skin response is reduced by 20 per cent when painful stimuli are applied to the anesthetic area. This probably indicates a modification of the reaction, but Sears did not feel that it could be accepted as conclusive without further investigation. Dynes obtained results similar to those of Sears.

Galvanic Response in Children: Richter (6) studied the electrical resistance of the skin in the new-born infant. He found this resistance much higher than in the adult. The height of the palmar resistance was correlated with the sleep of the infant. Jones (3) studied the galvanic response in eight infants between the ages of three and eleven months. He found no difficulty in obtaining this response at this age. The basic characteristics of the response were similar to those found in older subjects. He reported that the initial resistance tends to be lower in infants than in adults. The most effective stimuli for infants were "fear and anger." Wechsler, Crabbs and Freeman (1, 2), using some thirty children between the ages of two and four, have correlated the galvanic response with emotional ratings given these children by their teachers. They found correlations of +0.35 to +0.65 with several of the criteria used. They failed to

find age differences within their group. The most effective stimuli were loud noises and tipping, and the least effective were verbal. Jones (2) also studied the galvanic response in preschool children. Porter and Copeland experimented with children between the ages of eleven and seventeen. At the age of eleven, girls gave fewer and weaker galvanic responses than did boys in an association experiment. At the age of fourteen the galvanic responses for the boys and girls were about equal, while from fifteen to seventeen the girls showed more galvanic responses. Aveling obtained positive correlations between the galvanic response and character ratings of children for " force of character," " desire to excel," " rapidity of decision," etc., which traits are, in his opinion of a conative character.

Galvanic Response in Animals: Gebhardt investigated the galvanic response in the dog. He found physiologically that the dog's skin reacts just as does the human skin. Ischlondsky (2) reported that it is difficult to establish the conditioned galvanic response in frogs and almost impossible in dogs and cats. Richter (7) has made a study of the recovery of the appearance of the galvanic response in cats after complete transection of the spinal cord at the level of T_1 or T_2. He found that when these animals have recovered from the operative shock (a period of 10 to 30 days) the galvanic response could be elicited. Erbs studied the galvanic response in the horse and dog and found it difficult to elicit in certain individual cases because of the restlessness of the animal. Buytendijk and Eerelman studied the psychobiological and adaptive nature of the response in the frog.

General Reviews: The review and bibliography of 316 titles given by Landis and DeWick, which appeared in the BULLETIN in 1929, is the most extensive so far collected. Gregor (2) reviewed the literature from the physiological viewpoint and summarized a great deal of the German physiological and neurological work on this subject. Landis (5) appended a bibliography of 58 titles which bear on the psychiatric use which has been made of the galvanic response. Eda has prepared a Japanese review of the literature and gave a bibliographic summary preliminary to Ueno's study of fatigue. Ciampi and Alberti are reported to have reviewed the literature. Bayley gave a bibliography of 140 titles with her monograph. Gildemeister (2) summarized his own research and that of others who have investigated the problem physiologically, in a chapter in a recent *Handbuch.* Strohl (8) gave a fairly full bibliography, particularly of the French studies, which have been made on electrical conductivity of living organisms. Höber reviewed the literature on the

electrophysiology of skin and other living tissues from the standpoint of physical chemistry.

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AN EVALUATION OF FIFTEEN RADIO TALKS IN PSYCHOLOGY BY MEANS OF LISTENER'S REPORTS *

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I

On October 17, 1931, the Psychology Committee of the National Advisory Council on Radio in Education began a series of fifteen minute psychological broadcasts. These broadcasts were given every Saturday night at 8:45 Eastern Standard Time, over WEAF and a network of approximately fifty stations associated with the National Broadcasting Company. The geographical distribution of these stations ensured coverage of most of the United States. Each broadcast was in lecture form, and was delivered personally by a distinguished psychologist. Dr. W. V. Bingham, as chairman of the Psychology Committee, was in charge of these programs. Much of their success is due to his knowledge of the requirements of broadcasting and unstinted effort in arranging the talks. Dr. Bingham has set down his suggestions for the preparation of radio talks in a recent article,[1] and has described elsewhere the entire project of broadcasting psychology nationally.[2]

In connection with these weekly broadcasts the Psychology Committee prepared listener's notebooks. Each notebook contained material to accompany a unit of five lectures. The first three units were (1) Psychology Today, (2) Child Development, and (3) Our Changing Personalities. Eighteen thousand, nine hundred forty-six of listener's notebook number 1 were distributed, 11,080 of number 2, and 5,058 of number 3. In each notebook a questionnaire or report form was included. Since these report forms may be referred to in the listener's notebooks they are not reproduced here.

* This study of listener's reports was made possible by the interest of the Payne Fund, of New York City, in radio education.

[1] Bingham, W. V. "The Making of a Radio Address." *Education on the Air—1932.* Columbus: Ohio State University Press.

[2] Bingham, W. V. "An Experiment in Broadcasting Psychology." *Radio and Education—1932.* Chicago: University of Chicago Press. Pp. 27–35.

The number of listener's reports sent in for the talks on Psychology Today was approximately 210, the number for Child Development 110, and for Personality 95. The relation between the number of notebooks distributed and the number of reports returned showed per cent returns of 1, 1, and 2.

The report forms asked for information in reply to the following questions: (1) How well was your radio working? (2) How interested were you in this address? (3) How much did you get from the lecture? (4) How effective was the speaker? (5) On the whole, did you like this address? and (6) Did you discuss the talk afterward? The listener was permitted to make an A, B, or C rating for each question in connection with each speaker. The particular meaning of A, B, or C rating was explained on the report form with reference to the individual question.

Besides this rating of the broadcasts the listener was requested to make comments on the talks and to state what topics or questions in Psychology he would like to have treated in future broadcasts.

II

In analyzing these reports listeners were grouped according to age, sex, and occupation. Only a rough grouping was attempted. Five different age levels were taken: (1) below 20, (2) 20 to 29, (3) 30 to 39, (4) 40 to 49, and (5) 50 and above. Occupations were grouped according to the following scheme: T was used as a symbol for teachers, clergymen, superintendents and school officials, professors, instructors, librarians, and others of allied occupations. S was used for students. B was used for men in business and trade, mechanics, salesmen, bankers, administrators, and others of miscellaneous occupations. P was used for professional men such as engineers, doctors, chemists, lawyers, and others. H was used for housewives, mothers, homemakers, persons at home, and was applied exclusively to the feminine sex. BP was used for women of the business or professional class. Naturally such rough classifications can only give an indication of the relation between listeners' reactions and their age and occupation. Since the analysis revealed nothing significant, only one of the tables is reproduced in this report (see Table II).

The chief difficulty encountered in interpreting the reports arose from the fact that the listeners tended to mark every speaker with an A rating. For example the listener would mark all speakers with the A rating and then make the comment that he enjoyed Mr. Blank much more than any of the others. This difficulty was overcome in

TABLE I

LISTENERS' RATINGS OF FIFTEEN PSYCHOLOGY TALKS GIVEN UNDER THE AUSPICES OF THE NATIONAL ADVISORY COUNCIL ON RADIO IN EDUCATION

(The lower the number the more favorable the rating. Limits are 0 and 300)

Question Asked on Report Form	Group	Psychology Today						Child Development					Personality				
		Oct. 17. Psychology Today	Oct. 24. Human Management	Oct. 31. Learning and Forgetting	Nov. 7. Our Social Attitudes	Nov. 14. Schools of Psychology	Nov. 21. Growth of Infant Mind	Nov. 28. Children's Fears	Dec. 5. Anger: Its Control	Dec. 12. Social Behavior	Dec. 19. Adolescence	Jan. 9. Changes in Personality	Jan. 16. Growing a Personality	Jan. 23. Growing Older	Jan. 30. Personality Problems	Feb. 6. Broken Personalities
How well was your radio working?	Men	40	41	30	35	19	5	2	13	21	5	3	2	4	6	6
	Women	13	10	25	19	17	14	15	8	9	7	19	11	8	26	8
	Total	29	26	28	17	18	10	8	11	15	6	11	7	6	16	7
How much did you get from the lecture?	Men	126	84	69	64	63	68	60	45	72	52	48	57	60	48	53
	Women	83	59	36	53	55	42	55	40	48	40	42	48	50	45	29
	Total	108	75	56	59	60	56	57	42	61	46	45	53	55	46	41
How effective was the speaker?	Men	54	44	45	55	52	36	39	52	58	33	33	22	50	32	71
	Women	38	34	33	37	37	31	26	31	34	19	20	22	30	35	34
	Total	48	40	40	48	46	33	32	42	47	27	26	22	39	34	53
On the whole, did you like this address?	Men	50	39	22	39	25	9	16	33	23	7	15	16	19	23	33
	Women	30	18	16	25	25	20	12	6	23	9	11	20	21	31	10
	Total	42	31	20	30	25	27	14	20	23	8	13	18	20	27	21
How interested were you in this address?	Men	41	42	30	33	25										
	Women	29	18	8	18	20										
	Total	36	33	21	27	23										
Did you discuss the talk afterwards?	Men						163	151	157	176	167	161	190	187	210	191
	Women						193	212	189	184	205	166	182	175	188	189
	Total						178	183	172	180	186	164	186	181	198	190
Approximate number of reports returned			210						110					95		

later report forms by the use of the principle of comparative judgments (*i.e.*, paired comparisons). In order to make the results easily comparable the data for the entire first fifteen talks have been incorporated in one table. It must be remembered, however, that this information is taken from three separate report forms and that in practically no case did one individual make a report on all fifteen of the talks. In fact many of the listeners reported on fewer than five of the talks.

The ratings given in Tables I and II have been obtained by assigning values to the letters used in the report forms. For simplicity of computation the letter A (good) was given the value 0; the letter B (fair) 1; and the letter C (poor) 3. The rating on any talk was then computed by adding up the A, B, and C judgments and striking an average.

Table I is read as follows: In answer to the question, "How much did you get from the lecture?" (second row) the rating given to the talk on "Psychology Today" was 108 for both men and women. For the men it was 126 and for the women it was 83. For the talk on "Learning and Forgetting" the total rating was 56. Naturally the lower the figure the more favorable is the rating.

The most obvious trend which these Table I figures show concerns the relationship between the rating and the position of the talk in the series. It is probable that those who were not interested in the talk dropped out and left only the more enthusiastic part of the original audience. The rank correlation between the position of the talk in the series and the opinion of the listeners as to how much they obtained from it was .77. It is curious to note that the relation between the number of copies of the talk distributed and the position of the talk in the series was also .77. The rank correlation between the number of copies of the talks distributed and the rating of the listeners as to the amount obtained from the talk was .55.

The rank correlations for the first ten talks with reference to the questions: "How much did you get from the lecture?", "How effective was the speaker?" and "On the whole, did you like this address?" were as follows: Between liking the talk and the amount obtained from it, .67; between liking the talk and the effectiveness of the delivery, .65; between amount obtained from the talk and effectiveness of delivery, .27. These correlations were made by adjusting the means for the first and second groups of five talks.

Women were almost universally more favorable to the talks than men as shown in the ratings. They did not, strangely enough, discuss

TABLE II

LISTENERS' RATINGS OF FIFTEEN RADIO PSYCHOLOGY TALKS ANALYZED WITH RESPECT TO AGE AND OCCUPATION FOR THE QUESTION: *"How much did you get from the lecture?"*

(The lower the number the more favorable the response)

	Psychology Today					Child Development					Personality				
	Oct. 17. Psychology Today	Oct. 24. Human Management	Oct. 31. Learning and Forgetting	Nov. 7. Our Social Attitudes	Nov. 14. Schools of Psychology	Nov. 21. Growth of Infant Mind	Nov. 28. Children's Fears	Dec. 5. Anger: Its Control	Dec. 12. Social Behavior	Dec. 19. Adolescence	Jan. 9. Changes in Personality	Jan. 16. Growing a Personality	Jan. 23. Growing Older	Jan. 30. Personality Problems	Feb. 6. Broken Personalities
Age															
Below 20	116	50	58	45	52	52	100	60	33	20	50	33	0	0	33
20 to 29	123	92	59	56	71	57	63	50	52	38	27	16	40	56	35
30 to 39	94	51	40	59	46	66	57	37	62	58	44	47	70	37	50
40 to 49	126	92	76	87	70	53	61	46	50	40	57	60	80	63	18
50 and above	44	35	36	23	42	50	50	33	80	51	20	26	28	28	17
Occupation															
T (teachers)	135	69	48	66	65	72	58	56	85	65	30	41	63	50	33
S (students)	120	82	63	52	63	90	100	66	45	46	25	25	11	10	37
B (business men)	67	74	69	70	66	42	46	35	84	50	44	57	69	33	53
P (professional men)	94	60	68	53	55	50	22	18	20	10	25	25	50	50	0
BP (business women)	31	50	42	58	33	50	40	20	33	16	44	50	30	36	9
H (housewife)	40	63	21	47	50	38	62	30	55	47	33	35	46	41	18

the child development series after the talk as much as the men, although they discussed the following series on personality more.

Table II gives the results of the detailed analysis in connection with the question, " How much did you get from the lecture? " The rating method used was the same as that noted for Table I. The table is read as follows: In row one, column one, it is shown that listeners below twenty years of age gave a rating of 116 to the talk " Psychology Today," a rating of 50 to the talk on " Human Management," and a rating of 58 to the talk on " Learning and Forgetting."

No important relationships between age and the rating of the talk (from the standpoint of information obtained) are shown. Those listeners below twenty and those above fifty seem to have stated that they gained the most. There does not seem to be any consistent relation between age and the type of talk preferred. For example those listeners below twenty years of age gave " Social Attitudes " the most favorable rating (in the first series) as did those aged twenty to twenty-nine and above fifty. The various occupational groups showed in a broad way a difference in the amount obtained from the talks. Teachers and students were in most cases much more critical of the talks and rated themselves as having obtained less from them than business, professional, and housewife listeners.

One measure of the effect of the talk is the range of the rating given by the different occupational groups. This shows that although " Learning and Forgetting " is given the preferred rating by the total group, there is a greater range in the response to this talk than for any other talk in the unit except " Psychology Today." The talk on " Social Attitudes " showed the most uniform response. In the first unit teachers and housewives obtained the most information from the talk on " Learning and Forgetting " and in the second unit it was the talk on "Anger: Its Control."

III

In an attempt to determine the factors associated with listeners' ratings of the various talks, the vocabulary which the speakers used was analyzed. Transcribed records of the actual delivery were not at hand so the printed copies of the talk were used. The words were checked from two standpoints. First the words were compared with Dr. Edgar Dale's[1] vocabulary list to see what their difficulty would

[1] Dale, Edgar. Evaluating Thorndike's Word List. *Educational Research Bulletin*, 1931, **10**, 451–457.

TABLE III

WORD DIFFICULTY OF TEN RADIO TALKS ON PSYCHOLOGY

Title and Date	Words Understood by Less than 80% of 8th Grade	Words Not Found in Thorndike's 10,000	Total No. of Difficult Words		Per cent of Difficult Words	Per cent of Different Difficult Words
			Not Different	Different		
October 17. "Psychology Today"	22	106	128	94	6.6	4.7
October 24. "Psychology: A Science of Human Management"	19	103	122	86	5.5	3.8
October 31. "Learning and Forgetting"	10	18	28	26	1.3	1.2
November 7. "Our Social Attitudes"	7	56	63	46	3.1	2.3
November 14. "New Schools of Psychology"	21	118	139	78	7	3.9
November 21. "Growth of Infant Mind"	17	77	94	78	5.3	4.4
November 28. "Children's Fears"	19	66	85	62	5	3.5
December 5. "Anger: Its Control"	18	55	73	47	3.5	2.4
December 12. "Social Behavior"	21	55	77	60	3.5	2.7
December 19. "Adolescence"	19	82	101	65	5	3.3

be for eighth grade children. The words Dr. Dale has tested are those contained in the first ten-thousand of Thorndike's and this was the second criterion applied to words. Table III gives the number of words (in the first 10,000) which would be understood by less than 80 per cent of eighth grade children as well as the number of words not contained in Thorndike's first ten-thousand words. Table III is read as follows: In the talk on Psychology Today there were 22 words (from Thorndike's first 10,000) which would be understood by less than 80 per cent of eighth grade children. There were in addition 106 words which do not occur in the first ten-thousand words of the Thorndike word list. Of these 128 difficult words in the talk, 94 were different, making a total of 4.7 different difficult words per hundred running words of the talk. Very interesting rank correlations were obtained between the difficulty of the talks as measured by the "different difficult word" criterion and the listeners' judgment of the talk. The rank correlation between the judgment of the listener with respect to liking the talk as a whole and the percentage of different difficult words was 47. The rank correlation between the listeners' judgment of the amount obtained from the talk and the percentage of different difficult words was 64. The separate correlations for men and women agreed rather closely. One would naturally expect that there should be a relation between vocabulary difficulty and the amount obtained from the talk, but one would not expect a relationship between the effectiveness of the delivery or voice of the speaker and the vocabulary content. This is borne out by a rank correlation of —03 between the effectiveness of the speaker's delivery and the percentage of different difficult words. A correlation of 13 existed between the number of different difficult words and the goodness of radio reception.

In interpreting these correlations, it is necessary to keep clearly in mind the fact that these results may arise from other factors not measured. As Dr. Bingham suggests, the relationship between simplicity of vocabulary and effectiveness of radio address may be due, not solely to the character of the vocabulary used, but to the fact that those speakers who use clear and understandable words are also often the very ones who devote the most thought and care to the selection of content and to other aspects of composition.

IV

On report forms number one and number three the listener was asked: "What topic or question in psychology would you like to hear discussed in later broadcasts?" On report form number one

the topics most favored for future broadcast were those dealing with (1) schools of psychology, including behaviorism and other forms, (2) learning and memory, and (3) social psychology, including the problem of making friends and getting along with people. It will be seen that these three suggestions corresponded closely to the actual talks given in the first unit.

For report form number three, filled out at the close of the third series, results were slightly different. Here abnormal and clinical psychology, child psychology, and personality were the topics most demanded. Again the demand corresponded to what the listener had just heard. This might be interpreted to mean that those listeners who took the trouble to fill out the report forms were naturally most interested in the subjects treated in the talks just heard.

From the suggestions of listeners on the report form for the child development series it was evident that play interests of children and measurement of personality are among the primary concerns of persons dealing with children. This seemed so whether the replies from men or from women were considered.

V

On report forms 2 and 3 the listener was given an opportunity to state whether he listened alone, with others in the family, or in a discussion group. Several people mentioned attending a discussion group in connection with the series on child development. For the series on personality a male student mentioned attending a discussion group of twenty persons. It is significant that even for the child development unit the students were the ones who usually listed discussion groups. Naturally enough these broadcasts have been used as discussion material in classes taking psychology. In some cases report forms were sent in for a whole class. As a rule somewhat more than half the persons reporting listened with their family. This was more true of men than women, and may indicate which sex has dominant control over the radio in the evening.

The listeners to the radio psychology talks were extremely varied both geographically and occupationally. Forty-four states and Canada were represented in the listener's reports, with New York, California, Pennsylvania, Illinois, Massachusetts and Ohio furnishing the largest returns. According to a rough classification system 71 different occupations were represented. These included persons in school work such as superintendents, administrators, professors, teachers; in office work such as accountants, bookkeepers, secretaries, and officers; in engineering; in various professions such as ministry,

writing, library work; in chemistry, medicine and nursing. Other occupations represented were yardmaster, foreman, mechanic, miner, shoe repairer, etc. It is evident that the psychology talks attracted a widespread interest in all classes.

VI

A great many personal comments were listed in the space provided for this purpose in the listener's report. A surprising number of these had reference to the time at which the broadcasts were given. Listeners criticized both the hour and the evening. Other comments bore on the length of time allotted to the broadcasts. The general conclusion on the part of the listener was that the broadcasts were too short. Not a person expressed himself as being in favor of a still shorter talk. Comments on this matter were scattered about equally through the three sets of listener's reports received.

The listener's reports made it clear that the listener's notebooks were of great use to certain persons in following the talks. This is in line with the general impression now held that radio education should be reinforced with printed material. Unfortunately, however, we do not have reports from those listeners who did not have notebooks.

An important aspect of the influence of radio talks is what people do after hearing them. Information concerning this is available in letters which the National Advisory Council has received and from other sources which are being investigated by the National Advisory Council at present. A few of the comments on the listener's reports also shed light on this matter. They show that listeners (1) told parents, congregations, classes, students, and others about the talks; (2) started discussion and notebook circles; (3) looked up books in libraries and asked for additional information.

Comments show that the talks have actually been related to the listener's daily life and that he felt they were of practical importance. Such comments were these: "Dr. Robinson really gave some working points which helped me greatly in my work." "The talk was practicable for my occupation." "I am very much interested in the psychology talks because I personally have a problem to solve and I feel that future talks on this subject would be worth hearing." "They have helped me to understand my pupils a little better." "I have been under the care of a psychiatrist for some time, not at present, but I feel that I have derived more through these lectures than his treatment.

Of course no attempt can be made in this report of the listeners'

comments to give many of the great number favorable to the broadcasts. This would expand the report considerably since listener after listener commented on benefits derived from the broadcasts. Such common comments were: "The lectures have been of great value to mankind." and "It is hoped that they may be continued." "They are unequalled by other programs." "They give ever-widening subjects." "They are instructive and interesting." "They are good, very profitable, thought provoking, and valuable." One or two of such comments may bear specific notation. "They (the talks) have established my faith in radio's educational possibilities." "One feels grateful for the benefit derived for one's self and for the community." "Your program excels by far any radio program in radio history, I think." "They were interesting to students of psychology." "I hope the time will come when you can supervise the children's programs. Many of them are not adapted to the child mind at all."

Possibly the most important comments are the suggestions made for improvement. From these comments many good ideas can be obtained for future broadcasts. A number of criticisms were leveled at the rate of speech and rate of presentation of ideas of the speaker. Specific mention was made that the speaker talked too rapidly and that the material was too crowded. However, many comments dealt with the fact that more concrete information was desirable.

A summary at the end of the talk appeals to many listeners. Suggestions were received as follows: "I wish the speakers would say what they are going to talk on, two or three points, then tell us and lastly summarize what they have told us." "I was helped by . . . especially the summaries at the end of the lectures heard. They cleared up a great deal of confusion." "I would suggest that the more important facts be summarized at the close of the lecture."

Suggestions on composition were that uncommon terms or words be explained and shorter sentences used.

Certain comments for the improvement of the talks concerned their relation to practical problems in the listener's light. These comments are given below: "The talks seem very clear but do not stimulate the listener himself to act. The importance of the facts brought out is not emphasized." "To me the series would have meant more if there had been more practical suggestions to cover the points discussed. I would like more help in daily problems." "Future addresses should be more practical." "I think it advisable in discussing physical ailments, glandular disorders, etc., that definite information should be given as to whom to go for a cure, or some

lead as to what steps to take." "How to choose a psychiatrist and when to go to him."

The suggestions made in the vast collection of comments can be reviewed somewhat sketchily as follows:

1. The talks should be of longer duration with greater detail and concreteness, but not with a greater number of general points.

2. The talks should be organized in a straightforward way with plenty of illustrations and with a summary at the end to tie up the points considered.

3. The talks should be related to the practical problems encountered in the listener's life.

4. Adequate publicity and tie-up to listener's notebooks or printed copies of the talks is important.

VII

As mentioned previously, the tables given in this report are only an indication and at most a guide to the person who intends to give psychological talks over the radio. There are in the listeners' comments suggestions as to types of material which will win listener attention. In a study of the actual continuity for the talks and its relation to the listener's response one may obtain insight as to the most suitable methods of presentation. Outstanding among these relationships is that between difficulty of vocabulary and judgment of the listener as to the value of the talk.

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INDEX OF SUBJECTS

American Psychological Association, A Historical Summary, 1
American Psychological Association, Proceedings of, 605
An Evaluation of Fifteen Radio Talks in Psychology by Means of Listener's Reports, 753

Editor's Note, 692
Educational Tests, 120
Effects of Castration on the Behavior of Mammals, 493
Eidetic Phenomena, 181
Electrical Phenomena of the Skin, 693

Financial Reports of Publication Enterprises of the American Psychological Association, 242

Habit Formation and Higher Mental Processes in the Rat, 461

Intelligence Tests, 93

Measures of Character and Personality, 147
Methods for Measuring Attitudes, 309
Midwestern Psychological Association, Proceedings of, 569

New York Branch, Proceedings of, 552

Perceptions and Mechanisms of Vestibular Equilibration, 279
Proceedings
  American Psychological Association, 605
  Midwestern Psychological Association, 569
  New York Branch, 552
  Southern Society, 381
  Western Psychological Association, 533
Psychology
  of Music, 218
  of Taste and Smell, 249

Recent Studies of Twin Resemblance, 204
Recognition of Facial Expressions of Emotion, 324
Relation of the Male Avian Gonad to Responses Pertinent to Reproductive Phenomena, 509
Report of the Treasurer, A.P.A., 177

Southern Society, Proceedings of, 381

Touch and Kinesthesis, 260

Western Psychological Association, Proceedings of, 533

INDEX OF AUTHORS

Achilles, P. S., 552
Allport, G. W., 356, 358, 359, 360, 371
Angier, R. P., 586

Beebe-Center, J. G., 355
Brown, J. F., 445, 448

Carmichael, L., 177
Carpenter, C. R., 509
Carr, H., 441
Commins, W. D., 493
Cronbach, A., 366
Crook, M., 120
Cunningham, B. V., 602

Domarus, E. von, 245, 246, 304, 305
Droba, D. D., 309

English, H. B., 569
Fernberger, S. W., 1
Foster, J. C., 457

Gamble, E. A. McC., 249
Griffith, C. R., 279, 401

Heron, W. T., 461, 531, 532
Hilgard, E. R., 440, 449
Holsopple, J. Q., 442

Jenness, A., 324
Jones, V., 120

Katz, D., 351
King, L. S., 424
Klüver, H., 181

Koch, H. L., 454
Kornhauser, A. W., 375, 377

Landis, C., 693
Lanier, L. H., 381
Lumley, F. H., 753

McAllister, W. G., 528
Mursell, J. L., 218

Nathanson, Y. S., 304

Partridge, G. E., 368
Paterson, D. G., 605
Peak, H., 600
Pintner, R., 93

Rexroad, C. N., 204
Rice, O., 360
Roberts, H. H., 373
Robinson, F. R., 440
Ruckmick, C. A., 451
Rulon, P. J., 363

Seashore, R. H., 533
Stone, C. P., 493

Tinklepaugh, O. L., 450

Viteles, M. S., 378

Watson, G., 147
Willoughby, R. R., 361

Zigler, M. J., 260

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